The Installation of Cast Iron Street Mains

BY

WALTON FORSTALL

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ILLUSTRATIONS.

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THE INSTALLATION OF CAST IRON MAINS.

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SYNOPSIS.

This paper treats solely of the installation of cast iron bell and spigot mains for low pressure distribution. It does not enter into the principles governing the design of such a street main system, nor is it concerned with any questions of maintenance. It is written mainly with the idea of aiding the beginner to obtain a certain knowledge of main laying in a shorter space of time than might be possible were he obliged to depend on verbal instructions and daily experience. It begins with the proper organization for a main laying staff, and how their duties are affected by the size of their operations. Then follows an enumeration of certain preliminary work that is generally necessary before the trench may be opened. Excavation, both earth and rock, is treated in great detail from the removal of the first paving stone to bottoming the trench. Pipe laying includes the number of men needed for laying small as well as large mains, with their individual duties, and tells each step in the progress of a length to its final resting place. The various classes of main connections are described, and the conditions under which they are required. There is a full discussion of cast lead and of cement joints, with a slight reference to lead wool. Bagging off gas, with the precautions this entails, is thoroughly considered, and the same is true of the no less important matter of purging mains. The conditions under which gas supply must be maintained during main laying are examined and explained. Then in proper sequence come the different methods of refilling trenches, and the arguments for and against contracting for repaving. Under recording, the paper describes several systems of main records as applied to new and to existing mains, and to large and to small companies. It concludes with a discussion of mains on bridges under surroundings usually met with in cities.

INTRODUCTORY.

The design of this paper is to describe in great detail the installation of street mains, including the requisite organization of the main laying force. It is meant primarily for the learner in distribution work, but the writer hopes that it will be of some assistance to older men, if only because it gathers in one place and in logical order, information that hitherto has not been thus available, concerning American distribution practice. As the paper forms part of, and is taken from, a much larger work, it contains no reference to the designing or maintenance of a street main system nor does it describe the equipment generally used. The inclusion of these subjects would have added too much to the existing many pages.

It is hoped that the early appearance of the paper will be taken advantage of by our distribution engineers generally, and that they will be prepared to discuss it fully in October, so that when it is embodied in the proceedings, it will represent not merely the ideas of one man or set of men, but, as interpreted in the light of the criticisms which undoubtedly it deserves, and should get, it will become a useful treatise on its particular detail of distribution practice.

ORGANIZATION FOR WORK.

SMALL TOWNS.

The proper organization of a force for the work of main laying will vary according to local conditions, as the sphere of operation is first, in a small town, or the growing fringe of a large city; or second, in the congested portion of a large city. It will also vary somewhat in any particular locality, with the length and size of the main being laid, whether small, viz., 12″ or under, or large, viz., 16″ or over. (In the future, the words small and large will be used in this sense when referring to main work.) In any event, the street main work should be under one man who, whether the superintendent himself (as would be the case in many companies) or not, will be con-

sidered for our purpose as being called the general main foreman, and will be referred to as the main foreman.

In the first case spoken of above, viz., a small town, or the growing fringe of a large city, the duties of the main foreman will be very general. He will make a prior inspection of all locations where work is to be done, plan the work, decide perhaps upon the character of and arrange for the delivery of the specials to be used, as well as all other material, exercise a general oversight while the work is being done, and inspect the site after completion. In some instances, he will act as timekeeper and also check any reports made out by the gang foreman.

If the work consists almost entirely of laying mains to supply row after row of houses, or, as they are called in Philadelphia, "building operations," as the majority of these operations are begun in the spring and finished in the fall, and the most economical organization of the main force is that of a constant number of men, able, by working three hundred days in the year, to lay the miles of mains required annually, then, in order that the main and service work shall always be finished when gas is needed, or, as is more usual, when the builder is ready to pave street and footway, it often becomes necessary to lay a main in some streets soon after the house foundations are begun. This will sometimes mean that the proper line and grade stakes must be obtained from the city surveyor, and then the main foreman takes the gang foreman to the location and gives him, with reference to the stakes, all the information necessary in regard to opening trench. The two foremen also decide upon the best starting point and any other details in regard to the work, such as the proper character and location of the necessary specials, including drips, for under the conditions being described, there will be few underground structures encountered to cause unexpected changes in plan. As mentioned before, the delivery of this and any other material, and of tools and equipment will come directly under the supervision of the main foreman, and if the team used is also employed in hauling material for service work, the main foreman

will make all his plans for this team in conjunction with the service foreman, in order to insure its most economical use each day.

Where the recording of main work is done by the main department, the main foreman will generally make the necessary sketches, assisted by the gang foreman for such portions of main as may be laid and covered up in the absence of the main foreman.

To sum up, in the conditions now being described, the main foreman plans the movement of, and lays out in detail, the work of each main gang, and the gang foreman handles his men to get the designated work done with the greatest possible despatch and efficiency.

The composition of each individual gang will depend largely upon local conditions. For the Philadelphia work, in the growing fringe, where most of the laying is 6″ in dirt streets, and the average job is one block, or about five hundred feet, the following personnel has been used to great advantage:

1 gang foreman
2 caulkers
2 caulkers' helpers
14 laborers

In warm weather, a water boy should be employed to enable the men to keep steadily at work, and not be continually leaving the trench to walk to the water pail, disorganizing the work.

Experience has shown that with a good organization and a competent foreman, a small gang of this kind will turn out a splendid amount of work per man. Each laborer becomes a picked man and is worth the extra pay he gets. It is also surprising, if the proper brains be directing the main work, how constant may be the number of laborers to take care of what would seem to be a very fluctuating amount of building operations, as measured by the number begun each month. It is needless to say that where a gang is continually changing in size throughout the year, the output per laborer is appreciably lessened.

LARGE CITIES.

The second case spoken of at the beginning of this chapter, viz., where the sphere of work includes the congested portion of a large city, necessitates a change in the mode of working and more of an organization. The main foreman's duties will be largely executive, and he can have little detail work to do, as he must be free at all times to go where needed. He will often have to confer with the official of other companies when changes of locations of gas mains, or other structures; are in question, or cases of interference, or damage, have arisen. So much of his time will be taken up in this way that he cannot have very intimate relations with the gang foremen, or lay out their work in detail. He must teach these foremen to be able to decide for themselves in ordinary cases. As he cannot follow any daily routine in his work, he should always keep in touch with his office, so that he can be reached quickly if necessary.

The gang foreman it will be readily seen, should be of a higher type than is needed in situations where the main foreman looks after much detail. While the main foreman will have direct charge of the material delivery teams, the gang foreman will determine the material wanted, and its time of delivery. These orders will usually be telephoned to the office for approval by the main foreman, who, because of his knowledge as to the exact conditions of all his work, is best able to decide upon the details of their execution. Inasmuch as the careful routing of such orders as to distances traversed by heavy or light loads, does not appeal to the average driver, the main foreman is often able, by good routing, to decrease considerably the work of his teams. Beside knowing how to handle his men efficiently, the gang foreman must possess good judgment, not only in ordinary routine work, as for instance, in regard to the amount of trench opened ahead of pipe laying, but also in meeting any peculiar conditions that may arise in the absence of the main foreman. Instant action may be necessary to prevent loss of life, or damage to property, and

the gang foreman should be able to act quickly and have a fertile mind, and ability to reason carefully. When the gang foreman is not stationed for the day at any one particular location, he should keep the office in touch with his movements, preferably by telephone.

Neither the main foreman nor the gang foreman should be expected to make any sketches of the work done. To avoid all possible chance of misunderstanding, no job should be done except on a written order issued by the office and accompanied by a sketch giving in detail all available information necessary for the work.

The personnel of each main gang will be of a fairly high type, especially in caulkers and helpers, because the obstructions encountered and the heavy street traffic make pipe laying difficult. In Philadelphia a gang composed as follows is used:

1 gang foreman
4 caulkers
4 caulkers' helpers
16 laborers

In especial cases of tedious or dangerous work, the whole gang should be composed of experienced men.

For small jobs of changing mains, where backfilling follows immediately upon laying, such as laying around manholes, the gang would be as follows:

1 gang foreman
3 caulkers
2 caulkers' helpers
1 laborer

PRELIMINARY WORK.

PRE-INSPECTION OF SITE.

To insure continuity of work for a main gang, it is necessary to have always planned out ahead, jobs covering a week or ten days. A pre-inspection of each street is essential to ascertain what obstructions may exist along the proposed line of main. Where a building operation is in progress, there are often piles

of building material, mortar bed, plaster bed, etc. By giving the builder some days' notice of the time for beginning work, he will, especially if he is anxious to have the main laid, arrange to have a clear path for the trench. If is often necessary, however, to see various sub-contractors and to make several calls, and if possible the gang should not be shifted to any location until all obstacles are out of the way.

At this point it will be well to speak about one phase of preliminary work in connection with large main laying, that is peculiar to congested conditions, viz., the ascertaining whether at the location given for the trench, sufficient space will be found. Generally, before a permit is asked for from the City, or perhaps before a route is laid out for the main, test holes have been dug to ascertain the exact location of the existing underground structures. The frequency of these holes and their extent will vary, depending upon the conditions found. If it is apparent that there is plenty of available space, few test holes will be needed. If, however, conditions are very congested in the route and at the location finally decided on, then, unless the preliminary test holes were within one hundred feet of each other, it is advisable at some time before actually beginning the work with a large gang, to open a series of test holes covering two or three blocks, and thus definitely determine the exact location of the trench. It sometimes happens that this will be a zigzag line. As the work progresses, test holes may be opened for the rest of the route. It is always advisable to do this test hole work well in advance of the necessity for trench opening, especially if a change in location requires an application to the City. In length, the test hole should of course cover the space to be explored, and in depth, it should equal the probable depth of trench required. In addition a bar should be driven in several feet at various points in the bottom of the hole to make sure that no structure lies beneath.

DELIVERY OF MATERIAL.

The delivery of material, such as pipe and specials, should

also be arranged for. Where the force employed in main laying is fairly constant in size for several months, it is comparatively easy to estimate the weekly or monthly need for pipe. As to the yearly need, it has been found possible in Philadelphia to anticipate it very closely, and to place such orders with the foundries that carloads of pipe will be received as wanted, and more than 90 per cent. of the lengths hauled directly from the car to the street. This makes for great economy in handling.

In stringing the pipe, if 12″ or larger, it should be left with bells all pointing the same way, viz., in the direction in which the main will be laid. This direction should be whatever local conditions make most convenient, except where there is a grade exceeding 5 per cent., in which case the bells should always point up hill, reversing direction at each low point and summit. When the pipe is smaller than 12″, it does not pay to add to the expense of loading and unloading by requiring one direction of bells. The pipe should be strung as closely as possible to the curb and on the side of the future trench, except in the case of large pipe when the trench is some distance from the curb, and the excavated material will occupy all the space between curb and trench, so that the pipe must be rolled across the street as needed. Under ordinary city conditions, where the street is open to travel, the pipe must be properly lamped each night.

In addition to the pipe, certain special castings may be delivered on the street prior to beginning work. This is more apt to happen with large mains than small ones, for in the former case, there are often opportunities to economize by hauling the specials directly from the car, while the small specials, being ordered in large quantities, usually before the beginning of active main laying, are at the various store yards. Also, a large main job implies, as a rule, a length of one thousand feet or more, and the use of a minimum number of certain specials no matter what may be the underground conditions. This is not true of the average 6″ job under Philadel-

phia conditions, where, if laying from an intersection already in place, to the other end of a block, beyond which the development is uncertain, there may be no specials of any kind required. Again, if an intersection is to be laid, it may be known what tees and crosses are required, but the necessity for bends is uncertain, depending entirely on underground conditions, yet to be revealed. Therefore, it may frequently be more economical to deliver no specials until the exact needs of the job are known.

Fig. 1.—Service Cart. Page 10.

Concerning miscellaneous equipment, such as blocking, cement, lead, etc., it is a mistake to have on the street any more than is necessary to furnish economical hauling conditions from the store yard. Every pound of material left over on a job, to be transferred to the next site, involves unnecessary hauling expenses. Where cement is used, the more that is kept on hand, the more chance of spoiling from storms. One method of caring for small lots on the average job, where a shelter shed is not justified, is to pile the cement bags on the wooden blocks, high enough to avoid possible wetting, and then cover over with a water tight canvas.

NATURE OF EQUIPMENT.

The normal equipment for a main laying force depends, first, on its size, second, on the character of the main work, including the kind of jointing material used, and third, on conditions of paving and weather (winter or summer). The equipment listed below can be carried in the service cart (Fig. 1), and will suffice for the force described on page 10 when laying 4″, 6″ or 8″ pipe. For larger mains, additional equipment will be necessary.

1 Asphyxiation kit
2 Bags, 4″, 6″ and 8″
1 Bar, leak
1 Bar, rock pinch
1 Bar, search
2 Bars, tunneling
1 Brush, pipe, 4″, 6″ and 8″
1 Bucket, galvanized iron
6 Chisels, cape
6 Chisels, dog
8 Crowbars
1 Cup, drinking
13 Cutters, asphalt
12 Diamond points
Fittings and nipples, assortment
2 Forks, bag
1 Gauge, syphon U
2 Hammers, 14-lb. sledge
1 Hand saw, crosscut
10 Lanterns, red
10 Lantern rods (unless danger signs are used)
1 Level, small pocket
1 Level, 24″
300′ Line, ditch
1 Mattock
1 Oil can, squirt
15 Picks
15 Pick handles
5 Pins, ditch line
1 Pipe, smelling
1 pair Pliers, gas
2 Porters
2 Plugs, wooden, 4″, 6″ and 8″
1 Pump, bag
5 Rammers
6 Rods, canvas screen
1 6′ Rule
3 Screens, canvas
2 Shovels, flat nose, "D" handle
13 Shovels, sharp nose, "D" handle
1 Shovel, sharp nose, straight handle
15 Signs, danger
Soap and brush
2 Stoppers, 4″, 6″ and 8″
Tallowcloth
1 50′ Tape, canvas
1 Tapping machine, combination, with drills
2 Targets, ditch (either type)
3 sets of Tools, caulking
2 Wedges, asphalt
6 Wedges, concrete
6 Wedges, frost
3 Wedges, pipe bursting
1 Wrench, plug
2 Wrenches, Trimo, 14″
10 lbs. Yarn

For Cement Joints.

1 Board, mixing
1 bag Cement
3 prs. Gloves, rubber
1 Sieve, cement, 12″
1 Trowel

For Lead Joints.

3 Bands, pouring, 4″, 6″ and 8″
1 Bellows
1 Furnace, lead
1 Ladle, pouring
25 lbs. Lead

LOCATION OF EQUIPMENT.

When pre-inspecting the site, the location of such equipment as tool boxes (Fig. 2), tool wagons (Fig. 3), service carts (Fig. 1), etc., is usually determined. When there is much equipment a vacant lot is, of course, preferable to a roadway location. A footway location should be avoided, unless it is wide and little travelled. Ordinarily, an available and suitable location is in the roadway of an intersecting street at an end of a one-block job, or near the center of a larger job.

PREPARING FOR TRENCH.

The occasional necessity for line and grade stakes has been previously mentioned. It is always well to give the surveyor at least a week's notice. When there are no curbs at either side of the street, or at the intersections, stakes are needed. If either side, or intersection, has curb set, by obtaining from the surveyor the width of street, whether straight grade through the block, and if not straight grade, the location and height of the summit, then by means of tape line, level board, tees and targets, the height of curb, and therefore proper depth of trench can be determined accurately enough for most jobs.

The trench is marked out for the width required for the size of pipe being laid, the schedule in use in Philadelphia being as follows:

Size....	4″	6″	8″	12″	16″	20″	24″	30″
Width..	18″	18″	18″	22″	26″	30″	36″	42″

If the street is paved, both sides of the trench are marked with colored crayon, yellow or red preferably. One way of doing this is to locate each side of the trench from the curb every one hundred feet, and then stretch a line between each series of points, first on one side of the trench, and then on the other, marking along the stretched line. If there is no paving, a guide along one side of the trench usually suffices, being given by a rut marked by pick or shovel from a stretched line, or else the line may be left in place on the side opposite to which the excavated material is placed.

Fig. 2.—Tool Box. Page 11.

Fig. 3.—Tool Wagon. Page 11.

The pipe is also lined up on the opposite side of the trench to the proposed location of most of the excavated material. This ordinarily means that it will be on the side nearest the curb. In lining up, the bells should be pointed in the proper direction, and the pipe should overlap as nearly as possible the exact depth of joint. This will obviate any necessity for shifting pipe lengthways along the trench. Of course, the larger the pipe and the longer the stretch lined at any one time, the more will be the possible saving by careful lining. Where the lining covers the entire job, any shortage or excess of pipe will become evident at once. Where on large mains, the earth is thrown on the curb side, and the pipe strung across the street, it may not be advisable to line the pipe, but simply to roll it across as needed.

REMOVING PAVING

SEPARATING MATERIAL.

On a paved street there are usually several classes of materials to be removed from the trench, and each class should, if possible, be kept more or less separated. Asphalt pieces, or paving blocks, are generally piled, often forming a retaining wall for any large quantity of earth excavation. Bricks or rectangular stone blocks are often of use in making channels for conducting water flow under excavated material. Sand or concrete is kept free from any contact with earth.

In the ordinary case of a small main, the earth would be thrown on one side, and the paving material and base on the other, and the latter might be allowed to lay where it fell, not being in sufficient quantity to interfere with laying operations. Occasionally a streak of gravel, or sand, is encountered, and if it is of value for repaving or for other use, care is taken to keep it separate from the material. Where there is a loose or solid rock, the pieces are generally thrown clear of the earth excavation, so they will not be covered over and can easily be hauled away.

ASPHALT.

In cutting asphalt, the asphalt screen, Fig. 4, should always be used where there is any danger of injury to property or persons from flying chips. As a rule only one side need be screened, viz., that towards the footway—but if the trench is near a car track with much traffic, and open cars are in use, the track side will need a screen. Support for the screen is obtained by the device shown, and sometimes by tying to trees or poles.

Fig. 4.—Asphalt Screen. Page 14.

Each cut is made by two men working together, using asphalt cutter A, Fig. 5, one cutting right, the other left, and the line marking the side of the trench, forming the center of the cut. Each pair of cutters are spaced eight feet apart, the first pair cutting the right hand line, and the second the left hand line, etc. This staggering of the cutting work enables the whole gang to be closer together, and, therefore, under better supervision by the foreman. With a gang of not more than twenty men, it is advisable to place at work cutting, all the men that tools or space will allow, and finish this work quickly. In any

case, after all the cutting is finished, one man is given a regulation street broom and sweeps up all the chips, both those inside the screen, and any that may have passed over the screen and lodged on footway or roadway.

If the asphalt is on a concrete base, with both sides cut

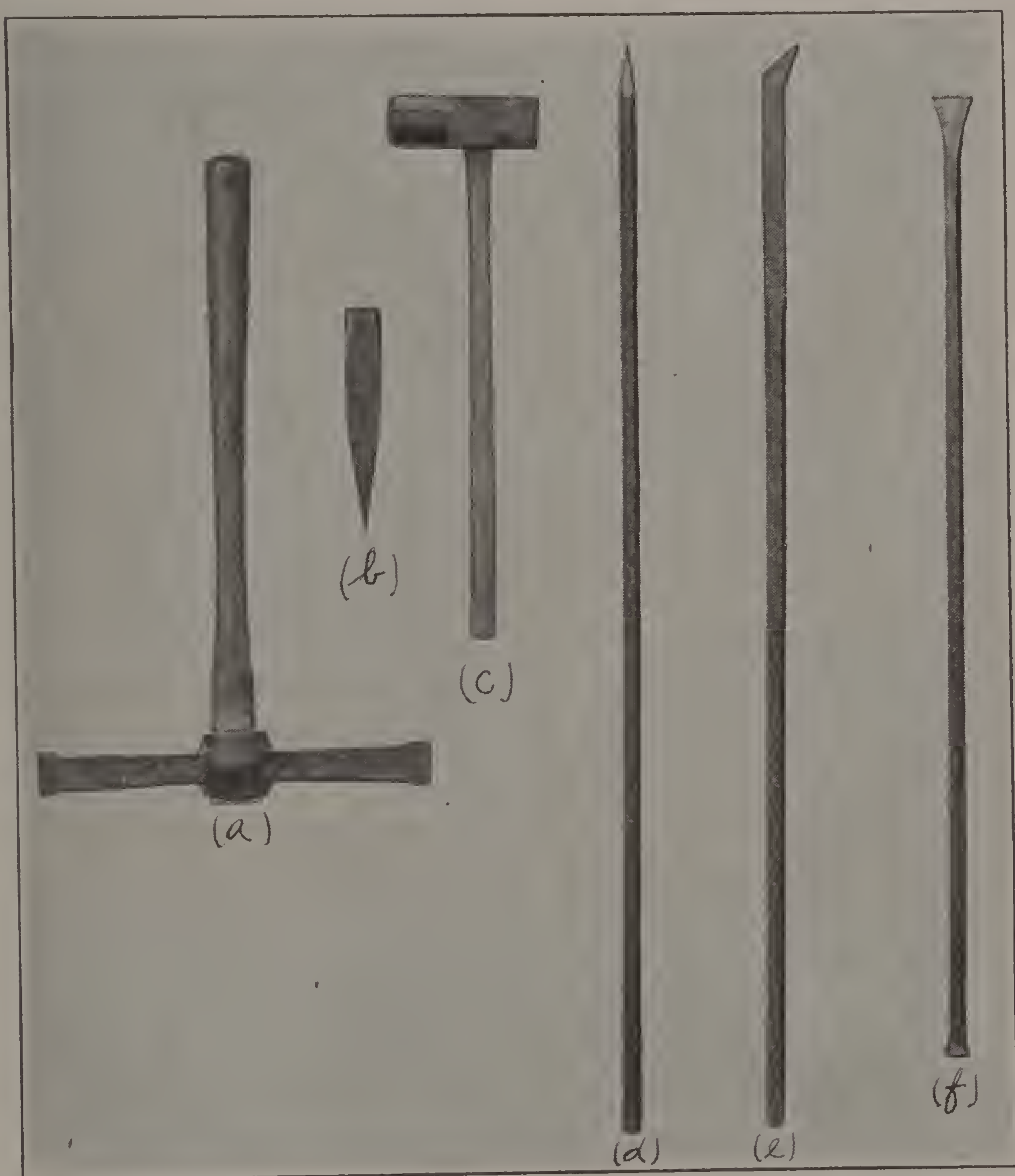


Fig. 5.—(A) Asphalt Cutter, page 14. (B) Asphalt Wedge, page 16. (C) 14-lb. Sledge for Breaking Asphalt, page 16. (D) Bars for Lifting Asphalt, pages 15 and 16. (E) Curb Lever, page 16. (F) Iron Tunnelling Bar, page 17.

through to the base, the asphalt can be lifted off with bars, D, Fig. 5, each lifting gang being composed of four men, viz., two men using the bars, one breaking the asphalt to pieces

with a 14-pound sledge, C, Fig. 5, and one man carrying away the pieces. As many gangs may be set to work as the width or length of trench will allow room for.

If the base is a rock or bituminous one, the asphalt is removed as follows: Asphalt wedges, B, Fig. 5, are driven in at the bottom of the cut towards the center of the trench, at an angle of 45° with the paving. Four wedges, all on one side, spaced about twelve to fifteen inches apart, are used at one time, driven in for at least six inches, and then loosened by hitting down on the upward turned face of the wedge. At the same time the asphalt is sledged on top at about the centre of the trench. Then the wedges are withdrawn, bars placed in the holes thus left, and the asphalt raised. With the width of trench as opened for small pipe, all the asphalt can ordinarily be thus raised from one side. If not, or on wider trenches, the same procedure of wedging and sledging must be followed on the other side of the trench. It is often advisable to begin to wedge up another section of asphalt before raising all the asphalt that has been loosened. By leaving in the last wedge, a better purchase is obtained on the next section. The gang is composed of six men, three handling the sledges and wedges, one alternating between the bar and the sledge, and two removing the asphalt pieces. At times the three using the sledges will aid on the bar in prying up the asphalt.

On a bituminous base, where the distance between cuts is over thirty inches, the regular curb lever, E, Fig. 5, may often be used to better advantage than the regular bar, D, Fig. 5, in lifting the asphalt after it has been loosened by wedges and sledges.

The asphalt once loosened, is broken up with sledges to a one-man size and piled preferably on the footway along the curb, in heaps about two feet by four feet by three feet high, with centre twelve feet apart.

OTHER PAVING.

Where there is vitrified brick, belgian block, asphalt block, rubble, cobble, or macadam paving, instead of marking the sides

of the trench by crayon, as before described, an alternative method is to drive in ditch line pins at points one hundred feet apart. Enough paving is removed to make room for the pins, which are driven in at an angle of 45° into the paving, pointing out from the centre of the trench until the head of the pin is almost flush with the paving. In this way the pins will not become loose as excavation proceeds. A line is stretched from pin to pin, and forms the guide for paving removal and for excavating.

For vitrified brick, belgian block and asphalt block, the removing gang is composed of one man barring out paving with the all iron tunneling bar, F, Fig. 5, one man standing in the trench, lifting the paving and throwing it towards the curb, and one man at the curb piling the paving material. For these classes of paving, and also asphalt, it is always best to remove paving by a special gang, and keep this work well ahead of the trenching, in order to avoid using the trenching force on removing paving.

For rubble, cobble or macadam, the trench is laid out in twelve foot sections, and each man removes his own paving with pick and shovel, throwing it off to one side of the trench, any additional moving and piling being done by separate men.

TRENCHING.

PRELIMINARY WORK.

PROTECTION OF THE PUBLIC.

Preliminary to, and also coincident with, the opening of any trench, certain precautions are necessary for the protection of the public, of the workman in the trench, and of the latter itself. Local conditions will determine in each instance just how many of these precautions are required.

Traffic, both roadway and footway across the trench, may have to be provided for. A footway bridge in its simplest form will be one or two planks laid across the trench, battened together, and with a plank on each side to act as a guard.

This will serve where the traffic is light and the job is of a few days duration. In laying large pipe, or long lines of small pipe, where important streets are opened, the footway bridges should be at least three feet wide and have sides three to four feet high. These bridges are moved from point to point as the work progresses, and six may suffice for even the largest job. No matter what form of bridge is used, attention must be paid to each end to prevent it becoming a cause of stumbling. Earth placed at the end will remove this danger and also hold the bridge in place.

Roadway bridges should be made from 3″ planking. Cross-pieces are placed across the trench about two feet apart, projecting fully two feet into each bank. Planks, parallel to the trench, laid on the cross pieces, form the floor of the bridge, which should not be less than eight feet wide, as measured between the guard railing put up across each end. The floor of this bridge should, as far as is possible, be level with the top of the street. Care should be exercised in making a good joint with the street surface at each approach to the bridge, and earth may be used to good advantage in this, especially where the bridge is somewhat above the paving.

Any trench for large pipe, or a trench for small pipe paralleling a car track, the excavated material in each case being on the curb side, should have a proper guard rail placed along the exposed side. This can be made by laying three or four pieces of 6″ x 6″, or 8″ x 8″, along the trench, about twelve feet apart centre to centre. To each piece a 1″ x 6″, three feet long is nailed as a post, and a 1″ x 3″, or 1″ x 4″ nailed to the top of these posts, forms a top rail. This rail is, of course, fairly flimsy and will need bracing at intervals.

In excavating under car tracks, any paving between the tracks, and for the space of one foot outside each rail, should first be removed and then 3″ plank laid in this space across the trench parallel to the rails, and projecting two feet into the bank on each side of the proposed trench. These planks should

be flush with the rail and well secured by driving earth in tight at both ends of each plank, after it is in position.

In the provision of bridges, as well as in any other steps necessary to minimize the inconvenience to the public, caused by main work, niggardliness, is apt to be poor policy, and a proper appreciation and provision for the rights of the public is quite compatible with efficient and economical operation.

Fig. 6.—Adjustable Braces for Shoring. Page 20.

The exact requirement as to free access to fire hydrants will probably vary in different places. Certainly excavated material should be kept at least six feet from a hydrant, and access to it both night and day provided, even if this means a bridge across the trench.

At night the trench and all material should be protected by danger lanterns.

PROTECTION OF THE WORKMAN.

The principal source of danger to a trench worker, viz., a cave-in, is generally absent in gas main work, because of the shallow trenches usually sufficing. If, however, because of deep excavations or unstable material, (as when the trench lies close alongside of a former trench), there is any question of the stability of the trench sides, the matter of shoring should receive careful attention. Usually a stretcher of 2″ x 12″, sixteen feet long in one or two lines, held apart by adjustable braces, Fig. 6, will suffice. Where sheet piling is required, 1″ x 12″ boards may be placed back of two lines of stretchers. Naturally, where shoring is resorted to, undue weight should be kept from the trench side, and this may mean in some cases a second handling of material to keep it back from the edge of the opening.

PROTECTION OF THE TRENCH.

Provision should be made to prevent any surface drainage flowing into the trench. Often such drainage must be conducted under the excavated material. At other times damming will suffice to divert surface flow away from the trench. There is no duty of the gang foreman more important than to have his trench protected from the results of violent rain storms. Where underground water is flowing into the trench, a pimp hole should be made, and a pump of either type in Fig. 7 placed in position. In most soils, the presence of water will be very disastrous to the trench sides, so the water must be kept down.

Under this head may be considered the necessity for marking at the trench side; the probable location of any water services crossing the trench. In each case the proper laborer should be shown the mark, and be cautioned to be on the lookout for the service when approaching the proper depth, in order to avoid any chance of injuring it.

EARTH EXCAVATION.

For small mains, the ditch line and pins mark the side of the trench opposite to the excavated material. Each man

measures off with his shovel a space of twelve feet, and is assigned this space for his work. This sectioning of the work affords an easy way of comparing the relative efficiency of each laborer. In each gang, it is advisable to have one or two men better paid than the rest and expected to serve as pacemakers.

Fig. 7.—Pumps for Removing Water from Main Ditch. Page 20.

If conditions are alike along the trench, the gang foreman expects all the sections to go down equally fast, and, in practice this pitting of each man against his fellows conduces to high efficiency. The men take more or less pride in finishing first, and the laggards are teased.

For large mains, both sides of the trench are marked by a

line. For mains up to 16″ inclusive, the diggers are expected to throw the material far enough to render unnecessary any subsequent trimming. For 16″ mains, the diggers are placed twelve feet apart, for 20″ and 24″, eight feet apart, and for

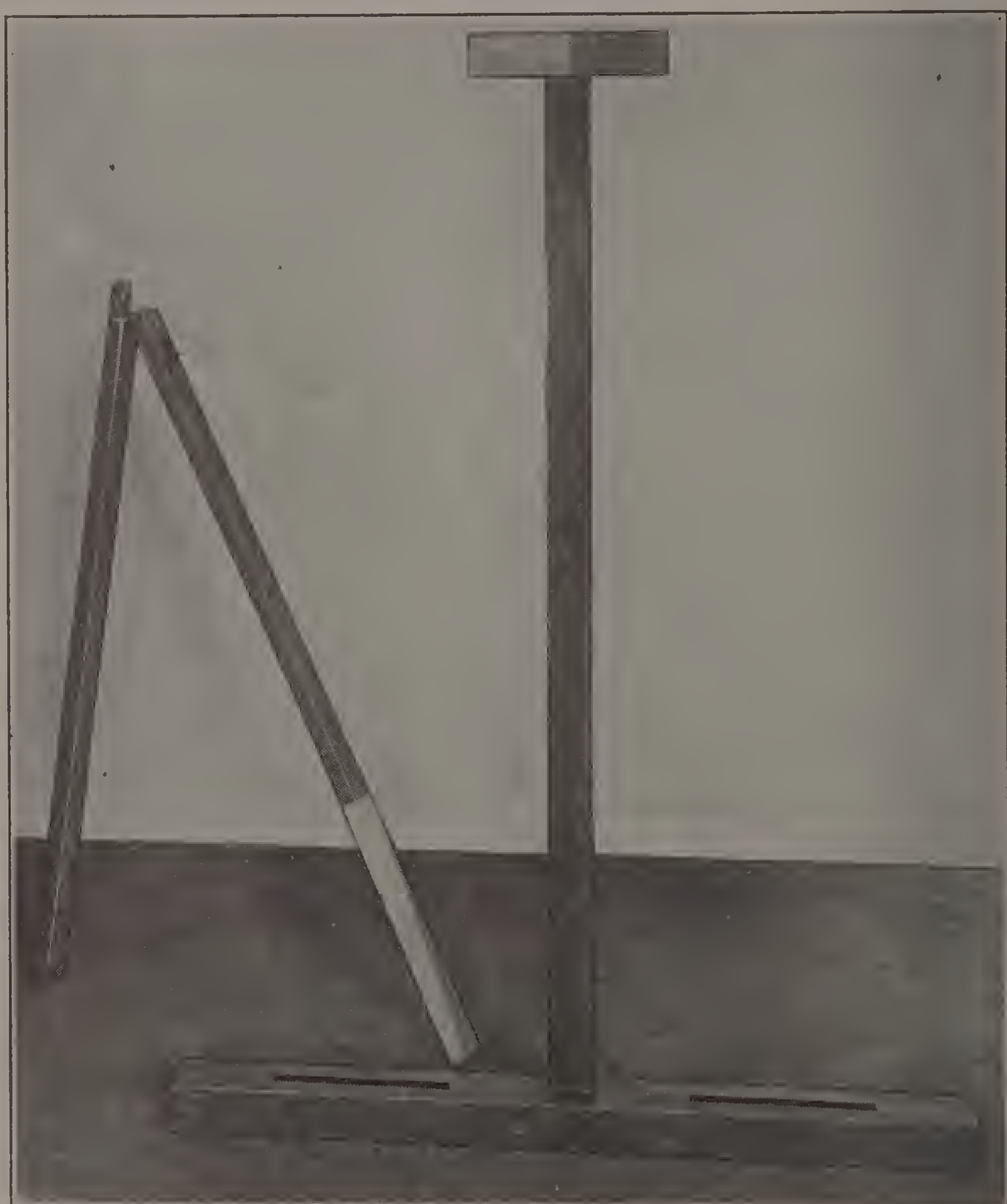


Fig. 8.—Ditch Target. Page 23.

30″, six feet apart. For 20″ and 24″, no trimming is done until the excavation has been completed. For 30″, at a depth of four feet, it is necessary to place one man on the bank to trim the material thrown out by every two diggers.

On every job, special men, such as caulkers, or pipe layers, are assigned to open over the mains to which connection will be made, and over any places where obstructions are expected, the places above described, being those which may disclose conditions affecting the depth of the trench, and which therefore must be known before any bottoming can be done.

Fig. 9.—Ditch Target. Page 23.

The considerations affecting the depth of a main do not fall within the scope of this paper. It suffices here to say that a cover of three feet may be regarded as standard.

After the depth of trench has been decided, the ditch targets, Fig. 8 or Fig. 9, are placed in position.

When working in frozen ground, one or more holes should

be made through the frost, and then by using the frost wedges, C, Fig. 10, and barring off from the face thus made, the frozen ground can be lifted off much as would be a concrete base.

ROCK EXCAVATION.

Where blasting is not necessary, as the rock may be removed by bars, A, Fig. 10, wedges, D, Fig. 10, and sledges, B, Fig. 10, the men work in pairs in a section so as to give each other assistance. The small spalls are thrown with the dirt on the opposite side of the trench from the large stone.

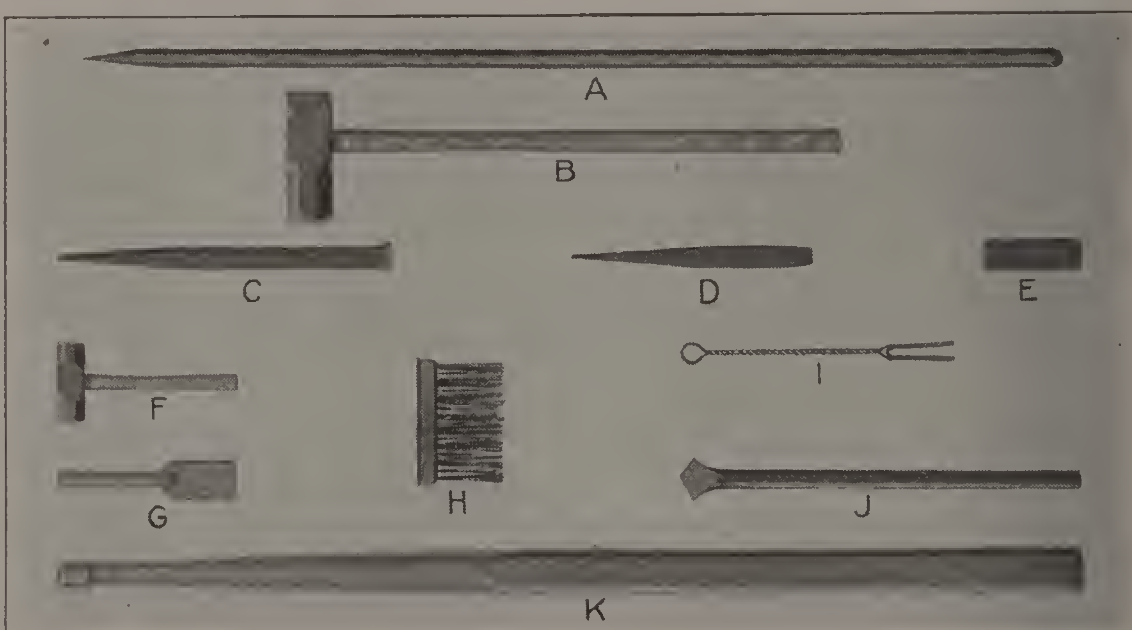


Fig. 10.—(A) Bar for Removing Rock, page 24. (B) Sledge for Removing Rock, page 24. (C) Frost Wedge, page 24. (D) Wedge for Removing Rock, page 24. (E) Bursting Wedge, page 36. (F) Caulking Hammer, page 52. (G) Cement Caulking Tool, page 52. (H) Wire Brush for Cleaning Cast Iron Pipe, page 26. (I) Bag Fork, page 66. (J) Drill Used in Blasting, page 24. (K) Porter, page 30.

Where blasting is required, three men form a gang, and the gangs work as close together as possible. One man holds the drill, J, Fig. 10, and two men strike. The charging, covering and firing of the holes should be delegated to one man, who should be an experienced rock man. Upon this man's judgment will depend the placing of the holes and the charge used. In general, the attempt is always to secure a face extending the full depth of the proposed trench. By staggering the holes in the various rows, the best progress is made. Where the rock

is very hard on small mains, it is advisable to start with a width of trench twice that required for earth. This will allow for failure to blow out to complete width in places. Often, of course, the trench will widen still more from blowing.

All firing should be done from a battery. Great care must be taken to be sure that all workmen and the public are at a safe distance before firing.

There should be a space of at least 4″ between any solid rock left in the trench and the nearest point of the main as it rests on its blocking. This is necessary to minimize the chance of future breaks, or leaks, due to later blasting operations when laying other structures.

LAYING.

ORGANIZATION FOR, AND DETAILS OF, PIPE LAYING.

LARGE MAINS.

The trench having been excavated, as previously described, is now ready for the pipe laying gang. Before telling of their work, the complete organization for laying 20″ and larger mains will be here given as follows:

One trenching foreman and eighteen men
One laying foreman and twelve men
One back-filling foreman and eight men

Better results are obtained by having one foreman over every separate gang, than are possible by attempting to work with only one foreman. If the general main foreman is not on the work frequently, authority in his absence should rest in one of the foremen, probably the laying foreman. The laying gang, if working steadily, would require more diggers and backfillers, but in practice, obstacles arise to interfere with laying, and therefore the laying gang is always used more or less to aid the other gangs.

The laying gang contains four caulkers, or joint makers, and eight pipe-men. As far as possible, the various routine

duties that arise should be definitely assigned to individual men, so that as the work progresses there is no confusion and each man becomes adept at his special lines of work. The foreman lays out the bell holes and starts his gang on them, also borrowing laborers from the trenching gang if necessary. Each bell hole extends from three feet in front of, to one foot back of the bell, clear across the bottom of the trench. Its bottom is four inches below the regular trench bottom, and its width, as measured along its bottom, is twenty inches greater than the trench width, tapering off to, and reaching, the trench width, fifteen inches above the proposed location of the pipe top. The material thrown out from the bell holes should be trimmed back, and there should be a two foot passage-way on the street on each side of the trench, before laying starts.

A dozen or more bell holes being completed, blocking is placed in position on the trench bottom. The "back" block is put with its near edge one foot back of the face of the bell, while the "front" block lies with its near edge three feet in front of the face of the bell. Back-filling will be reduced and the cavity under the centre of the pipe lessened if the trench has been so dug that the blocks may be set in the trench bottom so their tops will not clear it much more than one inch. This condition is difficult to obtain, however, and where there is insetting, care is necessary to ensure that the block rests on a flat surface, and not a concave one. The back blocks are set by spanning from one set to another with a level board set for the determined grade of the main. Or, each back block may be set by using a target. The front block is always set a little lower than the back block so that the main will just clear it.

The pipe which has been previously cleaned on the inside, and all dirt and scale carefully removed from the inside of the bell and the outside of the spigot end by a wire brush, H, Fig. 10, is rolled in position on the skids spanning the trench. The derrick, Fig. 12 is so placed that it will lower the pipe into the position desired. When moving the derrick, one man is at each of the rear legs and two men at each of the front legs.

(The front side is considered as the side on which the winch is located.) When in position and in use, the four men on the

Fig. 12.– Derrick. Page 26.

front side remain, but the two men at the rear legs are available for other work. The sling is adjusted so that the spigot

end will be slightly heavier than the bell. The pipe is raised until the bell end clears the front skid, which is removed by the proper man while another man bears his weight on the bell, thus causing the spigot end to clear the rear skid. This in turn is removed and the pipe lowered. If, because of obstruction, the pipe cannot be lowered at the point where it is to be laid, then it must be moved along the bottom of the trench by successive shifting of the derrick, or if the use of the derrick is not possible, the pipe is lowered upon a timber truck and rolled into position over a board platform laid on the trench bottom.

While the pipe is being lowered, there are two pipe men in the trench, one in front of the bell end of the length being lowered, and one just back of bell end of the last length laid, into which he guides the spigot end of the descending length, aided by the other man, who grasps its bell end. When the bell of the descending length is from a foot to eighteen inches above the blocking, and its spigot end has entered the bell end of the last length laid, the man on the derrick brake releases the latter and the length falls free. This causes it to strike the blocking with sufficient force to firmly bed the latter. The length is once more raised by the derrick to just clear the blocking, and is then pushed home with a bar by the man at its bell end. The foreman in the meantime has gotten into position to sight along the line, and if the length is in line, he gives the signal to lower. If not, he indicates the shifting required before lowering.

The length is prevented from getting out of line by the insertion of blocks and wedges between the pipe and each side of the trench, several feet back of the bell. These blocks are not removed until the earth has been refilled around the pipe along four or five feet at the centre of the length. In the case of cement joints, this refilling is always done before the joint is made, but in the case of lead joints, such partial refilling need not be done. Where the trench is at all unstable, this refilling is of great importance.

While this blocking is being done, the men who removed the skids have placed them across the trench, in the proper position for the next length, and rolled this length upon the skids in position for lowering, and are ready to assist in moving the derrick to the new position. From this point, the sequence of operations already described, is repeated.

As soon as the length is wedged in position, two caulkers start to drive in wedges on the front block, viz., the one under the spigot end of the length just laid, and raise this spigot end until it is central in the bell end of the length last laid. The joint is then yarned. At this time, wedges may be driven on the back block, care being taken not to raise the length off this block.

In laying pipe, it is often necessary to remove shoring. This work is done by the pipe laying gang, and may require the especial attention of the foreman to prevent too many shores being out at any one time, or too great delay in replacing shores, for carelessness in these matters may involve damage to both work and workmen.

SMALL MAINS.

For small mains, under the ordinary city conditions, where each job is only one or two blocks in length, the entire main gang will not exceed eighteen men, and will include two caulkers and four pipe men.

After the trench has been completed, or nearly so, and any special work of connecting to existing mains finished, the caulkers and pipe men are started on the bell holes. Each bell hole should extend from eighteen inches in front of the bell to the back of the bell, should have a clearance of six inches under the pipe and of fifteen inches on each side. Back of the bell hole, a notch is cut in the bottom of the trench for the block, but care is taken to make the top of the block slightly above the trench surface.

While the pipe is being laid, two men are in the trench, one a caulker with a spirit level and a bundle of yarn strips, cut to the proper length, at the spigot end of the length to be laid, and

the other a pipe man with a porter, K, Fig. 10, at the bell end. Three pipe-men are on the bank, and one inserts a porter in the spigot end of the length as it lies along side the trench, and lifts it. As it raises, a pipe man slides over the spigot end a loop of rope already made and resting against the end. He holds one end of the rope and passes the other end to a pipe man on the other side of the trench. The two men take up the slack on the rope, and then the man who raised the spigot end with the porter, goes to the bell end and pushes it off into the trench. The men holding the rope attached to the spigot end, prevent that end from dropping all the way to the bottom. The two ends of the rope are then taken by one of the two men, and he straddles the trench, while the man in the trench at the bell end raises this end with his porter. The length is thus suspended only a few inches above the trench bottom. The spigot end is caught by the caulker in the trench, who wraps a piece of yarn around it and enters it into the bell end of the length last laid. Is is then pushed home by the man at the bell end. Now one end of the rope is dropped, and after entering the spigot end, the caulker pulls the rope from around the pipe and walks to the bell end. Here he places his level on the pipe to see whether there is the proper fall. If not, the proper level is obtained by varying the blocking, the pipe being raised by the pipe man in the trench, and the caulker inserting the block which is handed to him by the pipe man on the bank, who had held the rope.

In the meantime, the other two pipe men on the bank have gotten another length into position for lowering, with the rope under it, as described before. The second caulker is following along, driving in the yarn put in by the first caulker. When all the pipe has been laid, or when it is desired to begin making joints, the foreman straddles the trench at one end of the line, and lines up the length by the aid of two pipe men who walk along in the trench, each with a long bar, one on each side of the pipe.

The procedure above described will care for mains as large

as 8″. For 12″ there is needed two more pipe men and another rope to be used at the bell end over a porter inserted in the bell. The rope at the spigot end will always require two men.

There will be instances where 16″ pipe may be laid without a derrick, and in that case it will be treated just as 12″ with the addition of two more men to the pipe laying gang.

CONNECTION WORK.

CLOSING GAPS.

The procedure followed in straight pipe laying has been pretty well covered, but some other necessary phases of main laying are still to be described. Every main laid is connected at one or both ends to existing mains, and often neither connection is made until the close of the work, and involves, therefore, the closing of a gap. Where 8″ and smaller, this connection can be made by "folding in" instead of sleeving, if the trench is free enough of construction to permit whatever deflection from a straight line is required for the "fold." As far as possible, it should be known before laying is begun, in what way connection will be made to the existing main. If by folding, then a gap two inches more than the laying distance of two lengths should be left. This will make the folding a little easier, and by distributing the two inches over the three joints making up the fold, no one joint will be very far from home. In folding, the far ends of the two lengths forming the fold, are put home in the ends of the lines to be connected, and then the adjacent ends of the folding lengths raised by ropes, until spigot will enter bell, when they are lowered into line, and the joints, if necessary, equalized, as indicated by each of the bells concerned in the "fold," being equally far from the line marked on its engaging spigot. This line shows where the bell should come if the spigot is home, and should be marked on every spigot forming part of a fold, where there is over half an inch slack to be taken up per joint.

For pipe, 12″ and larger, the use of a sleeve is usually preferable to folding. Much time has been lost through attempts to fold large pipe, in order to avoid the fancied disadvantages of

a sleeve and to save one joint, and often all the time spent was lost and the sleeve resorted to after all, especially if the foreman tried to work without any slack. The use of a sleeve will enable a spigot piece to be used, and in large work, where a stock of old spigot pieces may be on hand, the gap left should be of the right length to use up one of these pieces without further cutting. Where a pipe must be cut for the gap, its length should be at least one inch less than the distance between the face of the bell and the end of the spigot to be joined. This is especially important in very large pipe where the cut may break out a little jagged, and where an attempt to make a cut piece just the distance between bell and spigot, is apt to result in a piece too long at various points, necessitating a tedious cutting off of these projections. Naturally, in using the cut piece, the more uneven end is put into the sleeve. Before the cut piece is lowered into the trench, the sleeve is placed over the spigot end of the gap, and on this end and also on the end of the cut piece to go in the sleeve, a line is marked seven inches back from the end. Then the cut piece is lowered and put home in the bell, the sleeve is slipped forward over the gap and placed so that each face is equidistant from the marked lines. Such a sleeve joint involves an air gap of at least an inch longer than the bell depth. Unless the sleeve used is provided with internal ridges to serve as a joint backing, this gap should be covered by sheet metal to prevent any chance of the yarn and lead, or cement, from either sleeve joint finding their way into the pipe.

CUTTING PIPE ON BANK.

The procedure in cutting pipe on the bank is as follows: The proper length is marked off from either end of the pipe at four points at least. If the measurement is made from a bell end, the necessary allowance must be made for the bell depth. The pipe is then rolled until a line has been drawn completely around it, through the marked points. Before cutting begins, it is placed on skids, one under the end farthest from the cut, and the other under the cut, and care

taken to see that it stays there. No support at all should be placed under the short end. The skids should be as solidly placed, and as nearly level, as possible, in order that the pipe will not jar out of position during cutting. Each skid should be long enough to allow at least one and one-half revolutions of the pipe. For pipe, 12″ and smaller, one man holds a dog chisel, one strikes with a fourteen pound sledge, or ten pound striking hammer, and a third rolls the pipe. For larger pipe, there are two men striking, and a man at each end of the pipe rolling it and keeping it in proper position. In every case, a continuous cut is made around the pipe, and is a comparatively light cut, not more than ⅛″ deep. On the completion of this first cut, the cutting continues around the pipe as many times as may be necessary until the pipe breaks. With proper care, a clean cut will always be made. If for any reason the pipe breaks off irregularly, and the result is one or more places two inches shorter than desired, another cut will probably be required, unless the irregular end can form part of a deep sleeve joint. Any projection beyond the desired line can be cut off, but comparatively light blows must be used, to prevent cracking back of the line.

CONNECTING TO EXISTING MAIN.

At times the new main will be connected at the start to the existing system, and laying proceed without leaving any gap, gas being kept back by bagging. In such a case, it is, of course, imperative to do the connecting first. When a gap is left, however, the connection and any necessary alteration to the existing main need not be done at once, and as such alteration is usually harder than straight pipe laying, some foremen have a bad habit of putting it off till the end of the job. As a rule, expense will be saved by doing all the work necessary to close the gap except the actual closure, early in the job. It has already been noted under "Trenching," what an influence the connection to the existing main has on the bottoming of the trench.

In connecting to existing mains, the Philadelphia schedule is as follows:

Schedule of Main Connections.

Size of New Mains	Size of Existing Mains									
	30″ Hat Flange	24′ Hat Flange	20″ Hub Sleeve	16″ Insert Branch	12″ Insert Branch	8″ Insert Branch	6″ Insert Branch	4″ Insert Branch	3″ Insert Branch	2″ Insert Branch
4″	"	"	"	"	"	"	"	"	"	"
6″	"	"	"	"	"	"	"	"	"	"
8″	"	"	"	"	"	"				
12″	Insert Branch	Insert Branch	Insert Branch	"	"					
16″	"	"	"	"						
20″	"	"	"							
24″	"	"								
30″	"									

As is seen, the idea is to use a hat flange wherever the disparity between the connecting mains is very great, and the largest so large that a hub sleeve would involve heavy cost. As the disparity and the size of the largest main decrease, hub sleeves are used, and the ordinary branches. It is not always possible to follow the schedule strictly. Occasions arise where local conditions force the use of a hat flange, or hub sleeve, because of no room to insert a branch.

INSERTING BRANCH.

In mains below 12″, the insertion of a branch is not attended with any special difficulties, but with large mains, the work requires considerable care, chiefly in regard to the cutting of the pipe and the bagging off of gas flow. The insertion of a branch will here be described without, however, any detailed description of bagging, as this will be taken up further on.

The location of the branch being determined, a sufficient length of the existing main is uncovered to afford room for bag holes on either side of the proposed cut, and it never pays to skimp in the question of the trench width either. Usually there is not much leeway in the branch location, but it is not advisable to cut a pipe nearer than one foot to any bell. By cutting a little from the spigot of the branch, and sometimes by reversing the branch end for end, a desired flexibility of dimensions may be obtained. When the exact location of the branch has been settled, then the two points of cutting are carefully marked on the existing main, and the pipe thoroughly cleaned at these points. The length of the piece to be cut out should be about one inch longer than the over all length of the branch. In determining the points for the cuts, the effect of the bell depth upon the location of the branch should not be overlooked.

After the line of the cut has been chalked on the pipe, if the latter is smaller than 12″, then by means of a diamond point chisel, a cut at least ⅛″ deep is made across the top semi-circumference. This cut is deepened by repeated going over with the diamond point until about half the thickness of metal

is left. The whole cut is then gone over with a cold chisel, after which the chisel is placed in the cut at the top and driven into the pipe. It is then removed and a bursting wedge, E, Fig. 10, inserted and driven home until the pipe cracks completely around in the line of the cut. The same performance is repeated at the other cut, and the cold chisel is not driven into the pipe until both cuts are ready for such driving. In this way, after the pipe has cracked at the first cut, and is temporarily soaped up, there is nothing remaining to be done at the second cut except the driving of the cold chisel and of the bursting wedge. When the section has broken clear, it is hammered out of line, or perhaps it may be necessary to break a few pieces out of it to free it. Of course, before the cold chisel has been driven in, bags have been inserted to stop the gas flow.

Where the main to be cut is 12″ or larger, the difficulty of making a crack already started in the cut follow around the uncut portion of the pipe increases very much with the size of the pipe, and in no class of main work is it more advisable to bear in mind the adage of "more haste, less speed," than in cutting large pipe in the trench. It will pay in the long run to cut just as large a proportion of the circumference (at least three-quarters) as can be gotten at. The cut is made in the same way as just described for small pipe. The cold chisel should be driven into the pipe not only at the top, but in several other places around the cut. Two bursting wedges should be used, and great care taken to see that they keep in the plane passing through the cut. Otherwise the wedge will not exert a pressure tending to crack the pipe along the cut, but there will be great danger that they will cause cracks to run into the main on either side of the cut. If the cutting has been properly done, the main will slowly crack all around the circumference as the wedges are driven in.

Where the pipe is 24″ and larger, it is often advisable to make three cuts, the third cut being about one foot from one of the other cuts. When only two cuts are made, and the length

of the pipe cut out is considerable, it sometimes happens that even after the section is cracked around the circumference at both cuts, it remains wedged in the line of main, and requires much work to get out. The reason for this is given in the next paragraph. Under these conditions, where there is a third cut, the bursting wedges are driven into it in such a way as to cause cracks each side of the cut, and to break off portions of the pipe. After that, it is comparatively easy to remove the first section, and then the rest of the cut out section.

In cutting a line laid with lead joints, the pressure brought to bear by the bursting wedges, seems sufficient to make the pipe take up at the joints adjacent to the cut, and thus the desired separation of the edges of the cut is obtained. With cement joints the strength of the joints is apparently too strong to be overcome, and so if the pipe being cut is under tension, or in other words, is at a higher temperature than when the joints were made, the desired separation at the cut will not be obtained by the wedges, and in that case it is necessary to cut around the entire circumference with diamond points and cold chisels, and dispense with bursting wedges entirely.

In every case, the pipe should be rigidly supported at each cut by blocking. Otherwise, there will be great danger of cracks being caused in the pipe on either side of the cut out section. If one of the cuts, say "A," comes back of a bell and nearer than a foot to it, and the other, say "B," in front of a bell, then it is advisable to force the wedges into "A" and sledge away the bell portion before driving the wedges into "B." This program tends to give a cleaner break at "B" than would otherwise be possible, but is only applicable when "A" is near a bell.

The process of inserting a branch after the section has been cut out, amounts to closing a sleeve gap, and has already been described.

PUTTING ON HUB SPLIT SLEEVE.

When the connection to the existing main is made by the use of a hub split sleeve, that portion of the pipe to be covered

by the sleeve, is thoroughly cleaned, generally with foundry brushes. Then the two pieces of the sleeve are loosely bolted around the main, to see first whether the distance between outside of main and inside of sleeve is sufficient for jointing room, and second, to mark on the main the location of the circular cut. The sleeve is then removed and the pipe diamond pointed along the marked circle, beginning at the top. The cut is then gone over with a cold chisel, going into the pipe, except for two inches at the top, where a lip is left to hold in place the piece being cut out. A soaped wooden plug, of proper size to fill the opening in the main, is kept on hand for use in case the piece drops out unexpectedly.

A ring of some soft material, yarn, or wire covered with rubber hose is laid around the out side of the cut, and the sleeve placed in position on the main and pressing on the ring, which forms a more or less gas tight joint, and also prevents any jointing material from either end of the sleeve, getting into the pipe. The flanges of each half sleeve, if planed, are coated with white lead, but if rough, a layer of mill board softened in warm water, is placed between the two flanges. All of the above bolts are drawn up hand tight and then tightened by wrench, no two bolts on the same flange being tightened in succession, but the progress being from one end of the sleeve to the other, alternating from side to side.

In making up the joints at each end of the sleeve, if the latter is provided with internal ridges, the work is similar to any ordinary joint. If there are no ridges, care must be taken, if lead is being used, to be sure that the yarning is so well done that lead cannot get back past the yarn into the sleeve. If it does, a mispour may result. If cement is being used, where there are no ridges, yarn is introduced from one end for about four inches into the lower half of the sleeve. Then cement is put in from the other end of the sleeve until the yarn is reached. As the level of the cement rises, more yarn goes in, until finally the sleeve is filled from the far end. The joint is driven from that end, and then cement introduced

at the other end to fill the four inch space. This cement is driven, and the both joints finished in the usual way.

The actual sequence of events is as follows: When the sleeve is bolted tight, a short piece of pipe, or a bend if necessary, is inserted in the hub of the sleeve. Then enough cement is put into the sleeve and the hub joint to make them gas tight. If a straight piece is in the hub outlet, a wooden plug is placed in the end of this piece. This piece is drilled to allow the passage of an iron rod, and with the latter the disc piece is knocked into the main. The rod is then withdrawn, the hole in the plug soaped up, and the sleeve and hub joints finished. If a bend is in the hub outlet, the former has been previously drilled by a hole so placed that a rod through it will knock out the disc piece. In the bend this hole, and in the straight piece a specially drilled hole, serves for a bag hole, when more pipe is laid.

PLACING HAT FLANGE.

In placing a hat flange, after cleaning the main at the desired position, the hat flange is tried for fit, it being desirable that there should be "iron to iron" contact with the pipe, especially at the bolt holes and around the edge of the opening. By covering the pipe with red lead and slightly moving the hat flange, the high points on the latter are indicated and chiselled off. When the hat flange is considered a sufficiently good fit, it is held in position, the mark made for the circular cut in the main, and the location of the tap bolt holes accurately centered by a punch provided with a bushing which just fits the bolt holes. Then the hat flange is removed, and the circular cut in the main made just as described for the hub sleeve. It is advisable to make this cut *before* the bolt holes are drilled, as otherwise there is danger of a crack extending between the cut and a hole, under the influence of the constant hammering while cutting.

A hole is drilled and then tapped exactly in the centre of the future opening, and into this hole is bolted the "dead man" or "old man." With it in this position, each hole in the main can

be drilled in succession and then tapped out, soap or clay being used to plug the holes as made.

The face of the flange is covered with white lead, over which a linen gasket, previously soaked in linseed oil, is placed, and the flange screwed down first hand tight, and then with a wrench, tightening in diagonal succession. Around each bolt is a piece of lamp wick. Of course, the material used between flange and pipe will vary with the individual using it. Mill board, canvas, lead, cement are all available. In general, the more nearly iron to iron the joint the better.

The details of inserting an outlet into the hub of the hat flange and of removing the disc from the main are exactly similar to those already described for the hub sleeve.

In placing hat flanges, a number of tools are needed which are seldom, if ever, used for any other kind of main work, and for this reason and also to ensure on hat flange work the presence of the necessary equipment, it is advisable to have this equipment contained in a special box, which is delivered on the work when required. The box is 8½″ x 8½″ x 2′7″ long, and contains the following equipment:

1 "old man" and attachments
2 6″ cold chisels
2 21/32″ twist drills with taper shanks
1 12″ flat file
2 gauges
1 4½ pound ball hammer
2 diamond points
1 centre punch
1 centre punch with bushing for centering
1 boiler ratchet with 11″ handle
2 ¾″ bolt taps with square shanks
1 single-head hexagon screw wrench

JOINTS.

YARNING.

For pipe no larger than 16″, one caulker only is needed to yarn a joint. The yarn is cut from 1½″ to 2″ longer than the outside circumference of the pipe, (and is not good practice

to use at any time, any length of yarn shorter than the outside circumference), as determined by taking one end of the yarn from the bale and passing it around the pipe After a number of pieces have been measured in this way and cut from the bale, a sufficient number of strands are taken from these pieces, to make when twisted together, a rope large enough to fill solidly when compressed by the yarning iron, the radical space between spigot and bell. The proper number of strands for the size pipe being laid, having been determined and twisted together, one end of the rope so formed is tacked in the right hand side of the joint by the yarning iron and pushed at least half way in. The balance of the rope is then stretched around the pipe, being carefully kept in its twisted state, and driven back half way. This method of working, brings the caulker around to the right hand side where the yarn was entered first, and he continues around a second time, driving the yarn home this time. In thus making two circuits of the pipe in yarning the yarn remains at all times more nearly in a plane perpendicular to the axis of the pipe, and there is little danger of disturbing the lap.

Where cement joints are used, only enough depth of yarn is needed to support the weight of the spigot end and keep it central in the bell without any chance of sagging while the cement is setting. Any more than this amount is uselessly occupying space needed for requisite depth of cement. It is very important that the yarn be solidly driven. Also for cement joints, the front yarn is cut and prepared for the drivers, and laid across the pipe against the face of each bell when back yarn is driven, or at any time after the pipe is lined up. This method saves the drivers from carrying yarn from joint to joint, it renders uniform the number of strands used, not leaving this to the drivers' discretion, and it prevents dirt getting into the joint.

Where lead joints are used, the depth of yarn is determined by the depth of the bell, and of lead required. Each layer needed is put in as was the first, but a new starting point is

taken, so that the lap of one layer does not come above that of a preceding layer. The most satisfactory way to determine when enough depth of yarn is in, is to measure back from the driving point on each yarning iron the depth of lead desired, and stop yarning when the point is touching the yarn and the mark is just hidden.

Mains 12" and larger, being blocked under the spigot end as well as the bell end, do not depend on the yarn to hold the spigot central in the bell, and, therefore, under these conditions, for cement joints only enough yarn is needed to prevent the cement getting inside the pipe. For mains over 16", two men are needed to yarn a joint. The yarn is inserted and driven just as described for the small mains, except that each man works alternately on his half of the joint until the yarn is completely back. Then both men drive at the same time until the yarn is properly compressed.

Jute yarn of a middling quality should be used, with fibers long enough to form strands that will twist properly. In this yarn a certain amount of oil will always be present, but careful buying will eliminate any bales with an excessive amount. Tarred yarn should be avoided, as the tar squeezes out under driving and deposits a film on the iron surfaces, which is detrimental to the tightness of lead or cement. For cement joints, some men use yarn soaked in grout, but the general preference is for dry yarn, both at the back of the bell and for driving, as it is considered advantageous to soak up some of the water squeezed out of the cement by driving. On the other hand, for lead wool, yarn with a slight amount of tar is advisable in order to form a compact mass against which to drive the first lead wool strand. By using dry yarn for the last strand, the tarry film is apparently sufficiently wiped off, to cause no leak with lead wool.

The exact weight of yarn required per joint will vary not only with the depth of yarn used, but also with the tightness of the driving. The schedules below represent New York

practice with cast lead joints, and Philadelphia practice with cement joints:

New York City			Philadelphia	
Size of main inches	Depth of yarn inches	Weight of yarn ounces	Depth of back yarn inches	Weight of all yarn ounces
4	—	—	¾	6.0
6	2	2.0	¾	7.5
8	2	2.5	¾	9.0
10	2	3.0	—	—
12	2	3.5	¾	12.0
16	1¾	4.0	¾	17.0
20	1½	4.5	¾	21.5
24	2	5.0	—	—
30	2	6.5	¾	32.0
36	2	7.0	—	—
48	2½	8.0	—	—

LEAD JOINTS.

A discussion of the relative advantages of a lead, as compared with a cement, joint will be given when describing the latter joint.

Although depth of bells have been more or less standardized, there is much variation in the depths of lead used by different companies for the same sizes of pipe. Below is given the Philadelphia schedule for sizes to 30″ inclusive, and the New York schedule for 36″ and 48″:

Size of Main.									
4″	6″	8″	12″	16″	20″	24″	30″	36″	48″
Depth of Lead.									
1½″	1¾″	2″	2¼″	2½″	2½″	2¾″	3″	3½″	3½″
Approximate Weight.									
6 lbs.	9 lbs.	12 lbs.	22 lbs.	36 lbs.	50 lbs.	62 lbs.	75 lbs.	124 lbs.	165 lbs.

In considering any depths of lead, it should be remembered that the compression due to the most vigorous caulking does not extend deeper than about ⅞″ below the surface of the joint.

While the pipe is being laid and yarned, one pipe man has been assigned the job of building a fire under the lead pot and having the lead hot when needed. He also brings the red clay used for the pouring gate to the proper consistency. The first

step taken to pour a joint is when a pipe man puts on the rubber band, Fig. 13, being careful to drive it back closely against the face of the bell while tightening it. At the top, a pouring gate is made by the use of red clay, which is also smeared around the band where it touches the bell. The larger the pipe, the more important becomes all steps taken to

Fig. 13.—Rubber Band for Main. Page 44.

ensure the tightness of the band and prevent any leaking of lead.

For mains as large as 16″, the man who put on the band also pours the joint. He receives the ladle, A, Fig. 14, (or the pot for 16″, B, Fig. 14) from the man in charge of the lead pot. For 20″ and larger, two men are required to carry the

Fig. 14.—(A) Ladle for Mains 16″ and Smaller, (B) Pot for 16″ Main. Page 44.

pouring pot from the lead furnace to the trench. One of these men lowers the pot with a rope and hook and holds the weight, while the man who put on the band takes a hook and pours the pot. The other man goes back to the lead pot, fills a hand ladle, and stands with it resting on the pot, ready to bring it quickly if needed.

On 30″ work, two men are assigned to place the band, and one of these men stands along side the pipe while the joint is being poured, with clay in hand ready to stop any leakage of lead. Where it is necessary to use more than one ladle, or pot, for a joint, the interval between pourings should be as short as possible. If for any reason a joint should not be fully run and the lack occurs in the upper half, the surface of the lacking portion may be roughened, a gate made around it and very hot lead poured. If the lower half of the joint is lacking, it will probably be better to cut out the joint and repour.

When the joint has been poured, a short interval is allowed for cooling, and then the band is removed and placed on the next bell. The joint is now ready for caulking, and for mains up to and including 16″, there is but one caulker to a joint. A caulker should drive five 6″ joints each hour, four 8″, three 10″ two and one-half 12″, or two 16″, the lineal inches of lead as measured on the circumference being about the same in each case. For 20″ and larger pipe, two men are required to a joint, and the awkward position in which some of their work must be done does not allow the results obtained on the small pipe, so that for two men, two 20″ joints, one and one-half 24″ or one 30″ will be about the hourly result.

In caulking, the tools shown in Fig. 15, are used. The joint is first chiseled all around between the lead and the spigot, being careful to see that no scale, or fillet of lead, is left against the iron. After the joint has been chiseled, except at the gate, the latter should be cut off, but far enough from the face of the bell to allow sufficient lead for caulking. After chiseling at the gate, the caulker begins with his smallest tool and en-

circles the joint. He then repeats this performance with the next larger tool, and so on until he has used the largest tool possible for the size of pipe being laid. When this is done, the joint is completely faced, the lead will be driven about

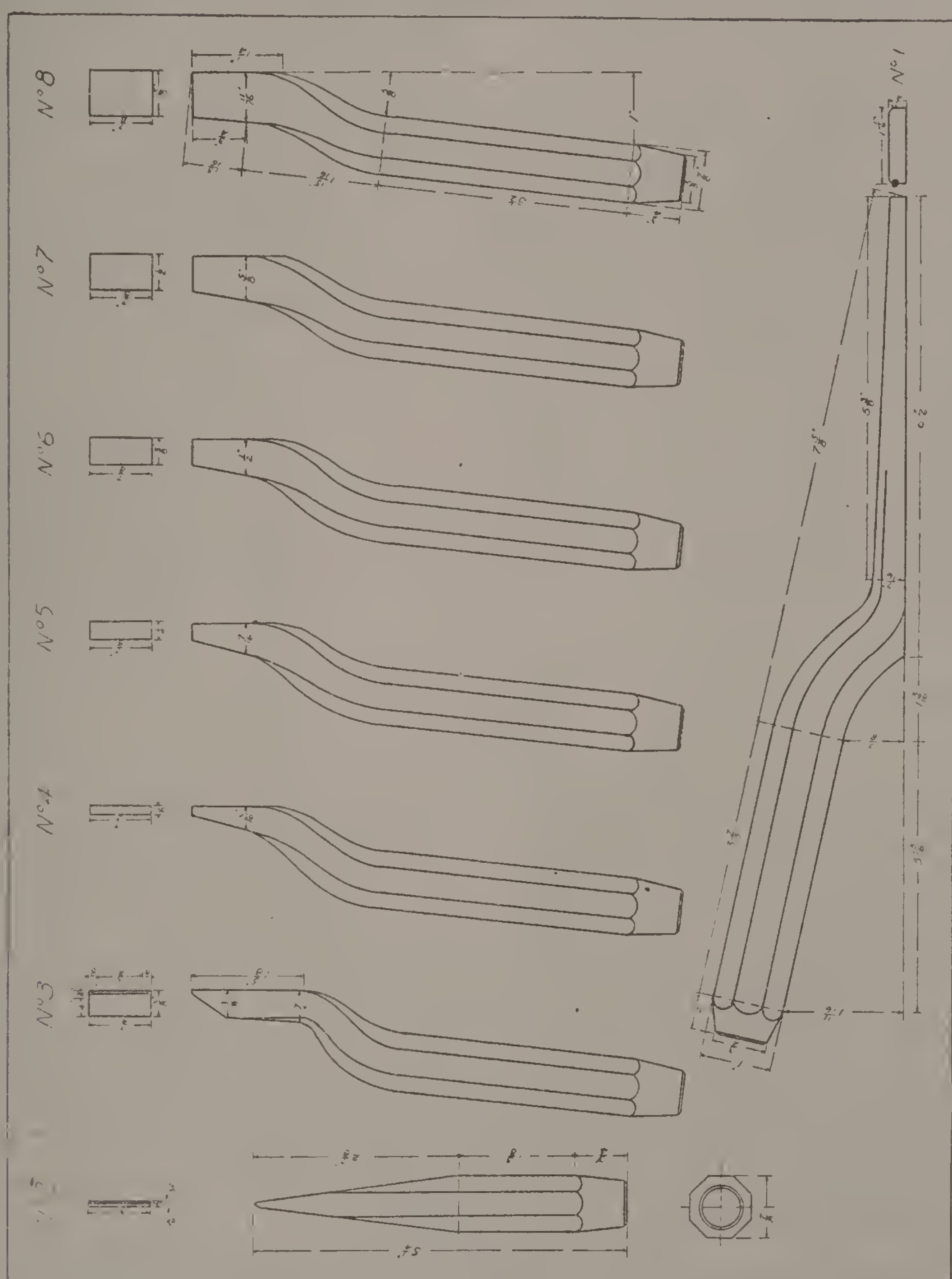


Fig. 15.--Tools Used in Caulking. Page 46.

flush with the face of the bell, and the joint could in ordinary practice be considered finished. Some experiments made in Philadelphia in 1901 showed, however, so much greater resistance to strains brought to bear on joints by deflection and tension, when these joints had been caulked twice than when caulked only once in the usual way, that it is the Philadelphia

practice to caulk all joints twice. In other words, after the joint has been caulked, as just described, each caulking tool is again used. Of course, this almost doubles the cost of caulking, which however, is not a large item in Philadelphia, due to the almost exclusive use of cement joints, as will be noted later on.

Each caulker should be provided with a steel stamp, containing a distinctive number or letter, and with this should stamp each joint made by him. This identification of work has a moral effect which is very favorable to good results, and enables the responsibility for a leaking joint to be placed against the original caulker.

The number of caulkers spoken of as forming part of main laying gangs, has been based on cement joints, and more will be required where lead joints are made, due to the longer time required for caulking lead, as compared with stuffing cement.

CEMENT JOINTS.

GENERAL.

The substitution of cement for lead as a jointing material for bell and spigot cast iron pipe is almost entirely a development of the last decade, but in that time many thousands of cement joints have been made with such favorable results on the score of tightness, and of economy in labor and material, as compared with lead, that the gas engineer using lead for mains under 20″ has the burden of proof against him. In Philadelphia, in the last thirteen years, 430 miles of cement joints have been laid, and in sizes under 30″ the number of leaking joints is about one to a mile.

For some time after the adoption of cement for most of the small main work in Philadelphia, lead was still used for small mains laid in the congested districts, and for all large mains. It was thought that as the tendency of 8″ or smaller pipe laid with cement was to break across the pipe rather than at the joint when under a stress, especially one due to construction, it was safer to use lead in all locations where other structures,

especially conduits, abounded, as it seemed preferable under those conditions to have a number of small leaks in lead joints, than one leak which might quickly fill conduits and manholes with an explosive mixture. Cement joints have caused so few broken mains, however, that the tendency now is to use cement joints in all small mains except possibly when the cover is very small, so that stress caused by traffic or temperature is apt to be great, or when the renewal of a joint would prove very troublesome. One advantage of a lead joint is, of course, that if it leaks, simple recaulking will usually effect a cure, but the cement joint must be entirely cut out, and the conditions under which the joint must be remade are not as favorable for a tight joint, as if the pipe was being laid for the first time. Dirt is apt to get into the joint, and perfect adhesion may not be obtained with particles of the old cement left clinging to the pipe. It is also quite evident that if the space surrounding the defective joint is rather confined, the man cutting out the joint may suffer from the effects of gas. For all the above reasons, therefore, lead joints are preferable in all special locations where future joint trouble is expected.

To return to the history of Philadelphia's experience with cement joints, at first it was not believed that cement joints could be successfully made for pipe 20″ and larger. When this problem was solved, as will be described later on, and the practice of using cement joints on large mains was adopted, it was still thought necessary to put in a lead joint at intervals to provide for expansion and contraction. It was believed that the joint might prove stronger than the pipe, as is generally true for pipe 8″ and smaller, and therefore that under severe contraction a broken main might result. Naturally a broken 30″ main was not to be desired. Therefore in laying a line of 30″ and of 20″ in 1902, lead was used for every eighth joint. A comparison of the distance apart of two marked points on either side of a lead joint in the 30″ line, as between August and January, showed that the total movement could be accounted for by the contraction in only twenty-four feet of pipe.

It is quite probable that the grip of the frozen ground against the pipe is much stronger than any stress due to temperature. In any event, as there were no cases of broken 30″ or 20″ mains, but only a few leaky cement joints, two facts were considered proven: First, that an expansion joint was of no use; second, that in a large main the joint was the weakest point. This last conclusion removed the final objection to using cement joint on large pipe. Ten years have shown a cement joint may leak after being tight for several years, and is then much more expensive to repair than a lead joint, but the saving in first cost is so great, especially in large mains, and the number of leaky joints so few, especially in small mains, that, as stated before, the user of the lead joints is put on the defensive.

It seems very probable that most cement joints leak not because of a temperature stress, but because of settlement of the pipe, and where a good foundation may not be secured, lead joints may prove cheaper in the long run. In this matter of settlement, it has been found advisable with pipe 24″ and larger, to let the pipe rest on the blocking at least over night, to allow time for the slight compression of the wood by the pipe that often occurs.

MATERIAL.

Undoubtedly Portland cement has been used almost exclusively for joint work, even in the early days when natural cement was so much cheaper. The material cost is, however, so small that few people felt justified in running the expensive risk of having leaking joints through using natural cement, generally comparing unfavorably with Portland cement in fineness and uniformity in composition. In Philadelphia, when starting cement joint work in 1899, the Dyckerhoff brand was used and proved generally satisfactory, except that at times there were complaints of lack of fineness. However, in 1903, American Portland cements began to challenge attention, and it was deemed advisable to test various brands to see whether one acceptable for cement work could

not be found. Not only could price be saved, as compared with the Dyckerhoff, but also certain inconveniences inevitable in buying an imported article be avoided. As a result of these tests, Philadelphia has been using American brands since 1903.

Each brand was tested:

First, for solidity under driving. This test consisted in noting whether the cement seemed to rock, *i. e.*, act more or less like quicksand when being driven. It is quite desirable, in driving a joint, that the cement will not rock, but will stay where put, so that in driving cement home at one part of the joint there will be no lateral displacement resulting in the cement rising up at other parts of the joint.

Second, for activity. A very quick setting cement would be objectionable, especially for large mains where the joints take some time to make.

Third, for soundness. The soundness was tested in several ways. Freedom from checking or cracking was determined by a standard pat test. Expansion was judged by pouring grout into some bottles, and ramming stiff cement into other bottles, and noting which bottles broke after setting. Where expansion is not due to impunities, it is an advantage for joint makers. Into some of the bottles red ink was poured on top of the cement. If any contraction occurred, the ink would find its way between the cement and the glass.

Fourth, for fineness. This is a standard test and was made with a No. 80 sieve.

Fifth, for adhesion. In this test a split sleeve was clamped around a pipe and by using grease on one-half of the pipe, a joint was obtained between the pipe and one piece of the sleeve only. Weights were suspended from this piece until it broke away from the pipe. The strength of a cement joint under ordinary conditions is measured by the adhesion of the cement to the iron under a strain acting parallel to the axis of the pipe.

MAKING.

The pipe having been yarned, and well secured from any possible movement, by blocking beneath it and by refilled earth

for three or four feet along the middle of each length, is now ready for the joint making process. On small mains the joint gang consists of one mixer, one passer, one packer and two drivers. The mixer has an iron wheelbarrow, a large pan, or a cement mixing board, measures for cement and water, and a small short handle hoe. The passer has a trowel and a pan, or a mixing board. The passer and packer wear rubber gauntlet gloves. The drivers have a caulking hammer, F, Fig. 10, and a cement caulking tool, G, Fig. 10.

The surface of the bell and of the spigot included in the joint have, before the pipe is laid, been very carefully cleaned. For this purpose a wire brush, and perhaps gasoline, has been used at least a day before joint making, in order to give the gasoline time to evaporate.

The mixer measures out a definite amount of cement and water, and mixes it into a thoroughly homogeneous mass. This mixing should be done in the shade if possible. There will always be more or less difference of opinion as to the exact quantity of water to use, some men preferring wetter cement than others, but in Philadelphia, the proportion recommended is three of cement to one of water by volume. This will make a mixture which will appear crumbly in the pan, and will just retain the impression of the fingers when squeezed in the hand. No more should be mixed in any one batch than can be used in the time before setting begins. This time will depend on the quickness in setting of the cement being used, as shown by the activity tests. Ordinarily, twenty minutes is the maximum time that should elapse from the mixing of water with the cement to the final work on any joint on which that particular batch of cement was used. The mixing pan, or board, should be kept scraped clean of all old cement. In practice, of course, it is hard to ensure that the mixer will always follow these rules relating to small and fresh batches, but the larger the pipe, the more certain it is that carelessness in these matters will mean leaky joints.

A batch being ready, the passer cuts from it with his trowel

a wedge-shaped piece and hands this to the packer, who is astraddle of the joint. The packer takes the cement from the trowel in his gloved hands and starts to pack the joint from the bottom. He works up both sides together, finishing at the top, using the sides of his hands and fingers to push in the

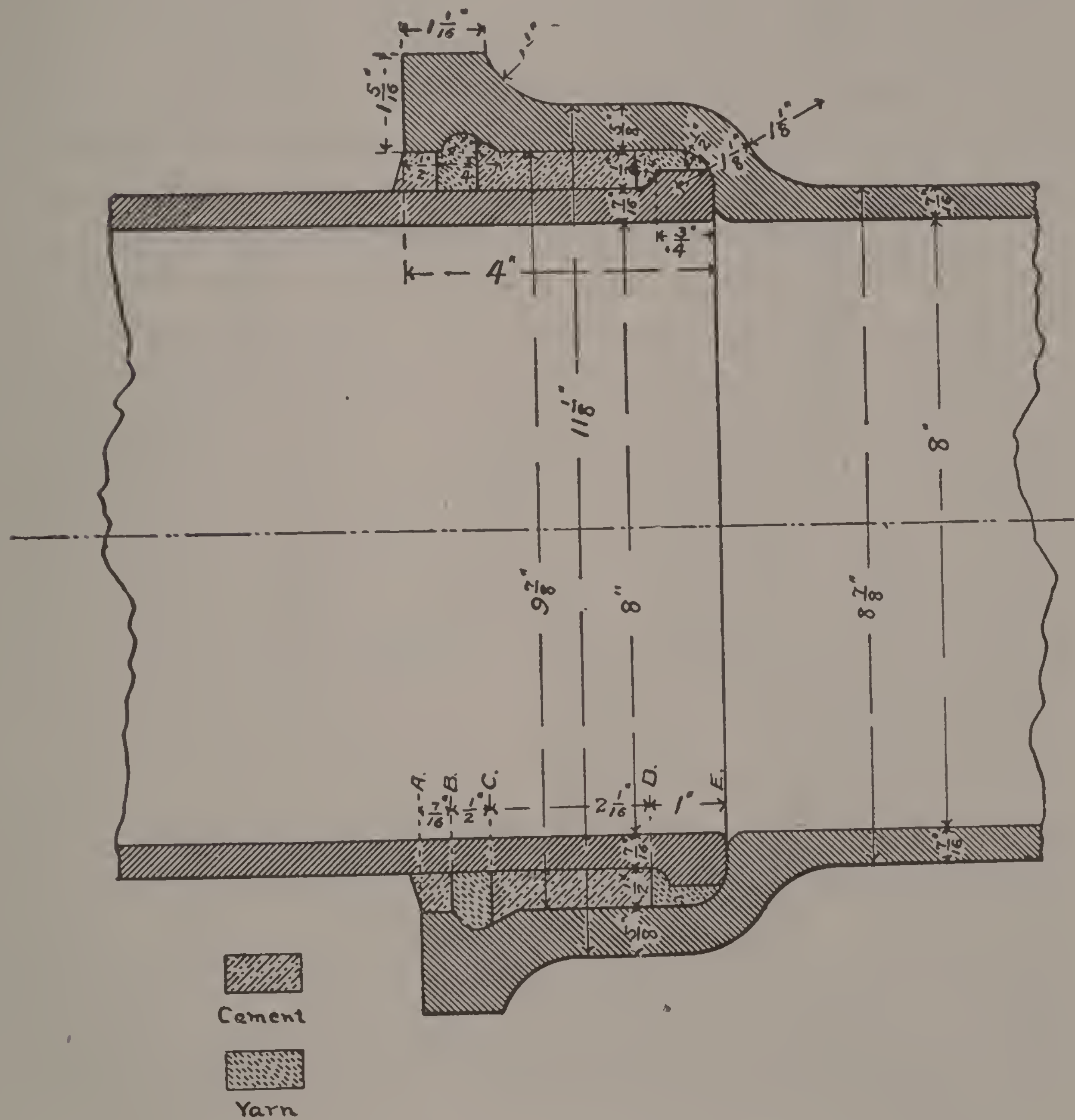


Fig. 16.—Cement Joint. Page 54.

cement. He considers the joint to be fully packed, when on pushing his fingers on the lower half of the joint, the cement pushes out beyond the face of the bell at some point along the upper half. When this is the case, he starts from the bottom and coming up simultaneously on each side, wipes away with

the finger tips of each hand, any cement on the spigot outside of the bell, and on the face of the bell itself. At this point in the process the cement occupies the whole space A-D, Fig. 16.

The driver now begins by taking up the yarn strands, already prepared for him, as described under "Yarning," and lying across the pipe. These he twists if necessary and tucks one end in on the left hand side of the joint near the top. He then starts to push the yarn in past the face of the bell, working down along the left hand side and up the right hand side to the starting point at the top. The yarn has then entered the bell all the way round, and the excess cement is scraped off by the caulking tool and drops to the bottom of the trench. Beginning at the first starting point, the driver now goes around the joint in the same direction as before, caulking the yarn until it feels solid under the caulking tool. The proper amount of driving to be done to a joint may not be described, but can be learned by experience only. It is quite possible to drive the yarn too hard. When the yarn begins to show moisture, this is a usual indication that enough driving has been done. The driving yarn then occupies the space B-C, and the cement the space C-D, Fig. 16.

After packing all the joints laid out for him, the packer starts at the beginning of the line, and fills the space A-B, Fig. 16 with cement, leaving a surface flush with the face of the bell as shown. This last fillet of cement serves merely to protect the driving yarn from the soil, not being gas tight itself. Rather wet cement of dough-like consistency is used, forty-five pounds being mixed at one time on 6″ work, enough to make twelve joints.

A gang of five experienced men following the procedure above described, can make fifty 6″ joints in an hour, or thirty-five 8″ joints, or twenty 12″ joints. For mains 16″ and larger, the gang is composed of one mixer, one passer, two packers and four drivers. The method of working is the same as for the small mains. Fourteen 16″, ten 20″, seven 24″ or five 30″

joints represent what can be done per hour by these eight men when experienced.

TEMPERATURE PRECAUTIONS.

While the use of cement joints on small pipe dates back for many years, it is believed that only since 1902 have cement joints on large pipe been successfully made on an extensive scale. At that time the Philadelphia Gas Works determined to use cement on its large mains if possible, and after a few weeks of failure, involving the cutting and remaking of several scores of 20″ joints, it was discovered that if the temperature of the main was kept nearly constant from the time the joint was stuffed until it had set, tight joints would be the rule and not the exception, even on 30″ pipe. Also, in order to throw the least possible strain due to temperature changes, on the finished joint, it is advisable to have the temperature of the pipe as close as possible to mean underground conditions. This, of course, is more easily, or perhaps only attainable, when main laying occurs during the spring or fall months.

Therefore, it is the Philadelphia practice to give preference to these months for large main laying, and this is usually quite feasible because the need for such mains is seldom so imperative that a delay from winter till spring, or summer till fall, is not possible. Small mains, of course, have to be laid at all seasons of the year, but fortunately, a given range of temperature during joint-making and setting does not seem to have the same harmful effect on a small, as on a large, pipe. Indeed some people do not believe it is necessary to take any temperature precautions when laying pipe 8″ and smaller, but such a course will often involve a risk out of proportion to the slight saving involved.

What are the temperature precautions to be taken? To begin with, if the pipe has been exposed to the rays of a hot sun long enough to become warm, joint making should not start until the iron has had a chance to cool to the air temperature. Ordinarily, pipe can be laid one day and joints made the next, in which case there is plenty of chance for the necessary

cooling. If, however, joint-making must occur the same day, it may be necessary to use water on both bell and spigot ends just before laying, to bring down the temperature quickly. Neither bell nor spigot should be left wet, for such a condition would add undesirable moisture to the cement. It may also be necessary when the pipe, after being laid, is exposed to a hot sun before joint-making, and there will be no chance of its cooling through atmospheric changes, to sprinkle it with water applied at frequent intervals by a sprinkling can, or to adopt any of the precautions decribed later on as being taken after the joint is made.

The most acceptable time for joint-making on a sunny day is in the late afternoon or early morning. The pipe being at about the existing air temperature, and joints having been made at either of these times, the problem is to prevent a range over 10° in temperature for the time intervening between joint-making and testing. What this time should be will be discussed later. If the time is twelve hours, making in the afternoon is preferable, as the night range of air temperature will usually be less than the day range in the sun.

The earth that has been refilled midway around each length, not only helps to keep the pipe securely in position, but protects the covered portion from temperature changes, so that only about four feet each way from the joint remains to be protected. There are several ways of doing this. One method very effective, but comparatively expensive and hardly necessary except perhaps for 30″ pipe, is to place a few inches above the pipe a platform of loose boards, itself covered by six inches of earth. The dead air space thus formed acts as an efficient insulator, and in very hot weather it may be found advisable to build the platform after the pipe is laid, removing it for joint-making and replacing while the joint is setting. Following this procedure on a line of 30″ laid in May, air temperatures *under* the platform varied in forty-eight hours from 56° to 61° only, while the corresponding range of the outside air was from 53° to 74°. This record is typical of what is accomplished by temperature precautions.

Another method of maintaining temperatures constant, which has proven quite acceptable under ordinary conditions, especially with pipe 20″ and smaller, is to cover the exposed portion of the pipe with coarse bagging, kept wet by sprinkling. If the days are hot and the nights cold, it is a wise precaution to let the bags dry out towards dark, otherwise evaporation might bring about a pipe temperature lower than normal. Still a third method, applicable if the trench is through a smooth roadway surface and not for pipe larger than 20″, is to stretch cheesecloth across the trench and by keeping this cloth wet, protect the trench from the sun's heat.

On cloudy days in spring or fall, often no precaution at all is necessary, and even sunny days at these seasons involve less air range between night and sun, than is true in summer. Severe winter conditions do not have to be considered because in such weather, no main laying is done, only repair work. In Philadelphia, cement joints are ordinarily used on this work, and resulting leaks, if any, have been few. The joints would be made as soon as the pipe was uncovered, and refilled right after making, so that ordinarily on winter work, the temperature of ground, pipe and air would not vary far from 30°, during the whole period from making to setting. In laying new pipe, it does not seem advisable to use cement joints when the air temperature falls much below 30°.

LEAD WOOL JOINTS.

Many slight modifications of the bell and spigot joints have been proposed from time to time, involving a change in the bell and spigot design, but have never met with any acceptance. In the last seven years, however, "lead wool," a special preparation of lead in a fibrous or shredded form, has been extensively used on mains 30″ and larger. Especially notable is its use in New York City on 48″ pipe. The fibers are put into the joint in the same way as yarn, each layer being caulked exactly as would be an ordinary lead joint. In other words, in making a lead wool joint, the whole set of caulking tools is used once for each layer of lead wool used. As a result, the

labor costs with hand caulking are, on large pipe, from three to four times as great as for cast lead. The material costs about twice as much per pound, but as less is used, the cost per joint is one and one-half times as much as cast lead. On long jobs of large mains, the use of pneumatic caulking tools has improved the work and lessened the cost, and an experiment is being made with a caulking machine, which will still further reduce the labor cost. However, the total joint cost will still exceed cast lead, and be so far above cement that, even though lead wool has almost a zero leak record, yet for pipe 24″ or smaller, the argument seems to favor cement. On 30″ pipe, cement shows more leaks than cast lead, and time alone will prove whether the leaks which may finally develop in cement joints in this size will outweigh the great saving in first cost. Above 30″, the choice lies between cast lead and lead wool. On isolated work, such as leak repairs, where size of pipe or temperature conditions preclude cement, lead wool will generally prove more convenient and, through saving in time, more economical than cast lead.

A fuller treatment of lead wool joints is impossible, both for lack of space and of personal experience. The files of the gas journals for the last five years contain all that has been written on the subject.

TESTING JOINTS.

The ordinary small main, laid for low pressure distribution, needs no test for tightness prior to refilling, save a test with soap suds under gas pressure. The necessity for any test has a tendency to delay main work and increase expense, and this is especially true where the test is made by pumping air into the main. Experience has shown that the test with gas is sufficient under the conditions described. The suds are applied with an ordinary shaving or other suitable brush, over the face of the joint and the adjacent spigot and bell, and any leak in the joint will be indicated by the presence of soap bubbles. There will be times when it is advisable to refill as soon as the joint is made and to omit any testing whatever, as for instance

where the trench cannot be kept open for any length of time, or when cement joints are used and temperature conditions are hard to maintain. In New York the success with lead wool joints has been so great that no test is made.

When the main is being laid by contract, or when it is larger than 12″, it is good practice to make a test under air pressure of three to five pounds. Observations of a pressure gauge in connection with a soap-suds test of all joints, will indicate the degree of tightness secured. If possible, the test should be made at a time when the range of air temperature is small, for in a large main there might be a stationary or slightly rising pressure, even when there are a few large leaks. Of course, the possibility of this occurrence is greatly increased if the line under pressure is quite long, as is often the case where each successive section laid is joined to the preceding sections and air pressure applied to the whole line. Where each section is tested alone, and the length of line under pressure does not exceed one thousand feet, the gauge is more independent of temperature, but at the same time temperature must always be borne in mind. It is possible with falling temperature, to have a falling gauge on a perfectly tight line.

When any fall in pressure cannot be accounted for by temperature conditions and yet every joint shows tight, a search should be made for a cracked pipe. It is a very foolish act to pass a line, especially of large pipe, on a falling pressure until every inch of main has been carefully examined.

For any volume up to 2,000 feet of 30″ pipe, the air pump, Fig. 17, is sufficiently large. For a larger volume, a steam driven pump could be used to advantage, unless the amount of use would not justify the outlay. Outfits are obtainable in which boiler and pump are mounted on a wagon frame, and so may be easily drawn from place to place.

Below follows a method used in Philadelphia for an air test. The test is usually made as near 7:00 A. M. as possible. The night before, all openings in the main are plugged up, the air pump is attached to the main, and the mercury gauge is

examined and made ready for attachment. In attaching the air pump, a 1¼″ hole is tapped either on the main or preferably, in the closing plug or cap. Sufficient 1¼″ pipe provided with suitable fittings to allow a ⅜″ connection with the gauge,

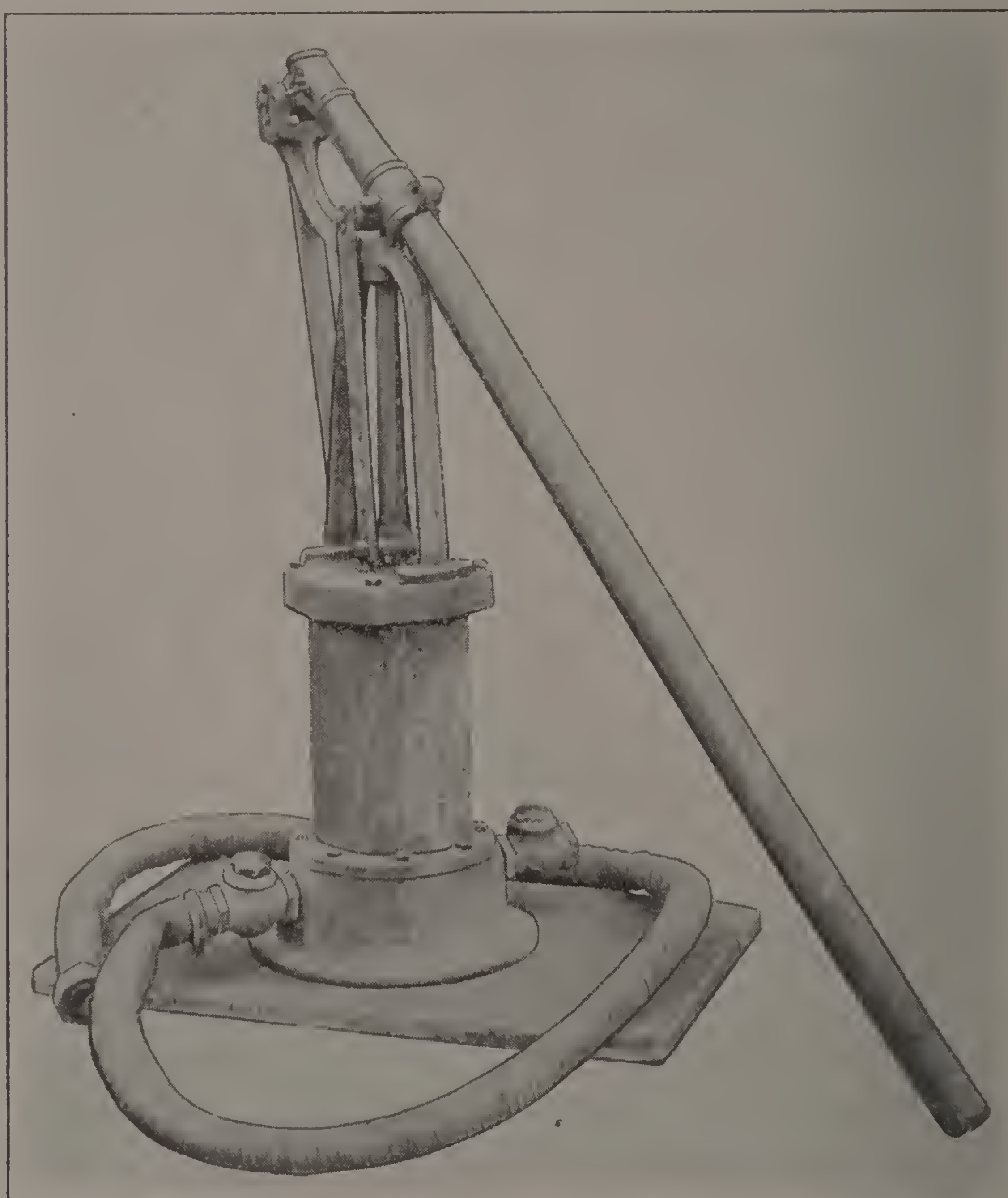


Fig. 17.—Air Pump. Page 60.

is used to place the gauge in a convenient point for observation. Armored hose connects the 1¼″ pipe to the pump.

Arrangements are made to commence pumping at such an hour in the morning that the required pressure will be reached at 7:00 A. M. With the pump shown in Fig. 17 for a pressure

of three pounds in five hundred feet of 30″, four men would be needed for two hours. The test is made by two men with pound brushes and a bucket of ivory soap suds. A foreman supervises the work and marks any leaks as found. When the test is completed, the pressure should be relieved through the standpipe or in any other way, before removing the plug or cap at the end of the section under pressure, as, if not, there is danger of injury to the workmen.

PRECAUTIONS AGAINST SETTLEMENT.

After a pipe is laid and covered up in a tight condition, the only reasons to cause breaks or leaky joints are some agencies, usually human, acting during subsequent exposure of the pipe; stresses due to street traffic and to temperature; and settlement of the pipe itself. The first danger must be guarded against by efficient line walking, the second and third are affected by the depth of the pipe, and the fourth, to which is due many leaky joints in all sizes of pipe and many breaks in small pipe, will be considered now.

Supposing, as is generally true, that the trench is in firm ground, the theory used to be that the pipe should be laid on this firm trench bottom, proper excavation being made for each bell. This theory worked all right in practice where obstructions were few, and therefore no occasion arose to decrease the expected cover of the pipe after the trench was bottomed; and, more important still, where the gang was small in number and contained one or more laborers skilled in making a bottom that lay in one plane, and was not formed of a series of small planes. The above conditions were never obtainable in towns of any size, and usually the result of laying directly on the earth was a line supported at a series of points along each length, and occasionally resting on refilled earth where the original trench depth was too great. Trouble has frequently resulted from such conditions, and, of course, more often with large pipe, with resulting heavy repair cost.

A little reflection will show that without any earth com-

pression, the support of a length lying on the earth, is a line about eleven feet long. If, as would be usually done, the pipe was allowed to drop on its bed several times, then *assuming* it always fell in the same place, there would be a concave bed probably several inches wide. Actually, however, it would be impossible to get any greater bed than one dropping would accomplish, and if such dropping did not leave the pipe in a straight line with the pipe already laid, a crook must be left in the line, or the bed disturbed.

The use of blocking obviates the difficulties above mentioned. The trench need not be carefully bottomed except where the blocking rests. In setting the block, paving rammer should be used to ensure that the block has a firm bearing over its whole area. Another good way of bedding the block is to raise the bell end of pipe about two feet, and then allow the latter to fall free on the block. The pipe can now be freely moved sideways on the block, or up and down by inserting distance pieces and wedges, with the certainty that its stability is not being affected. The use of wedges and of the distance pieces of 1″ board enables an exact alignment as to height, something impossible to obtain when laying on the trench bottom.

In deciding on the sizes of blocking to be used for various sized mains, there is ample opportunity for the use of individual judgment. Below is the schedule used in Philadelphia:

SCHEDULE OF BLOCKING.

	Size of blocking.			Size of distance pieces.			Size of wedges		
Size of mains	Thickness	Width	Length	Thickness	Width	Length	Thickness	Width	Length
3″ to 8″	3″	12″	12″	1″	12″	12″	1½″	4″	6″
10″ to 12″	3″	12″	18″	1″	12″	12″	2″	5″	8″
16″ to 20″	3″	12″	24″	1″	12″	24″	3″	5″	12″
24″ to 30″	4″	12″	30″	1″	12″	24″	3″	5″	12″

For services use 2″ x 8″—8″.

The blocking must always be used of full width and placed upon undisturbed earth. For mains over 16″, two blocks are laid side by side at each blocking point, making the width of four blocks for each length.

This schedule may be considered by some as being too

liberal, but it was designed with the knowledge that a few leaking joints under asphalt would pay for many feet of lumber. Two inch blocks undoubtedly could be used for small pipe, but 3″ will last longer, and the extra thickness may be needed some day to prevent settlement, where a block has been improperly imbedded. The blocks have been made short and wide rather than long and narrow, because the more nearly square the block is, the more apt is it to bear on its whole surface. A block which is almost as long as the trench is wide, will require great vigilance on the foreman's part to prevent many such blocks being set, resting on earth only at each end.

The surface area of the blocking for each size main as given, causes a pressure per square inch of such surface, which is the bearing surface of the blocking on the trench, varying from thirty-two pounds in the case of 8″, to ten pounds for the 24″, the weight taken being that of a pipe itself and a parallelopipedon of earth, three feet high, twelve feet long and of width equal to the outside diameter of the pipe. For pipe over 8″ in size, there are two blocking places in each length, and this enables a positive support to the spigot end, which is of great advantage in making cement joints, as it enables less yarn and more cement to be used, and prevents any settling of the spigot with a consequent leak. Where more blocking area is needed than will be given by two blocks to a length, four are used, two at each blocking place. In this way, 3″ x 12″ lumber can be used for all blocking, the only difference between the various blocks being in their length, and these latter have been so arranged that some of the larger blocks may be cut to form two smaller blocks.

There is only one objection worth noting to the use of blocking. This is the space left between the main and the trench bottom. The question of refilling this space will be considered later. As already stated, a little care in insetting the blocking in the trench bottom will reduce the space to rather less than one inch in height, and this care should be exercised especially with larger mains.

Blocking will care for the ordinary conditions of main laying. Where the soil is of uncertain stability, or the weight exceptional, as with some special castings, especial methods might be used. Short piles may be driven into the trench bottom at each side and the blocking rest on them. Concrete or brick piers may be built. Such piers are often advisable under specials, particularly bends used where the main changes in cover, and a big pile of blocking would otherwise be required. In every case, however, the pipe itself should rest on wood and not on the pier direct.

BAGGING.

NECESSITY FOR BAGGING.

No matter how small the pipe, no connection should be made to a main either by a cut out or by removing a plug or cap, without first stopping off the flow of gas. There are many workmen and some foremen who object to this precaution in the case of 2″, 3″ or even 4″ mains, and who, if left to their own devices, would often "jump in" a connection without stopping off the flow of gas. Such a practice, however, should not be tolerated, as it involves too much risk to the workmen, and also to the maintenance of gas supply on the main concerned.

In the old days of small mains, animal bladders served fairly well, and there was nothing better until the advent of rubber bags, which in turn, within the last decade, have been largely supplanted by stoppers.

Of course, the larger the main, the more dangerous would be the result of unrestricted flow, and, therefore, the more care that is necessary in the provisions for stopping off this flow. In Philadelphia, one bag or stopper must be used to prevent gas flow in mains 8″ and smaller, and two bags, or two stoppers, or one bag and one stopper, for larger mains. The last combination is to be preferred, especially in the very large mains, where the stopper is not apt to fit close enough to prevent a leak sufficiently large to bother the workmen. Ordinarily, a

separate hole is tapped for each bag, or stopper, and the latter is placed farthest from the opening, in other words, towards the gas flow, and takes up the pressure, so that the bag simply prevents what little gas may be going past the stopper, from getting into the portion of main being connected. This is on the assumption that a wrought iron "bleeder" pipe varying in size from 1" to 2" is inserted into the tap hole for the bag, and that through this pipe there escapes into the air, well above the top of the trench, any gas leaking past the stopper. There may often be cases when a bleeder pipe is not necessary. If so, of course the bag stands the full pressure differences, but the first stopper is the safeguard against any great gas flow, in case the bag should break.

SIZE OF BAG HOLES.

The schedule in use in Philadelphia, governing the sizes of holes to be tapped for the insertion of bags and stoppers, is as follows:

Size of main	Hole for bag	Hole for stopper
3"	1"	1"
4"	1"	1¼"
6"	1½"	1½"
8"	2"	2"
10"	2"	2"
12"	2½"	2½"
16"	*3"	3"
20"	*3"	3"
24"	4"	4"
30"	4"	4"
36"	4"	4"

*4" will be needed for the heavy canvas bags.

INSERTION AND WITHDRAWAL.

In inserting a bag, the procedure is about as follows: After the hole has been drilled, the portion of the main where the bag will rest, is carefully cleaned of any metal cuttings, or any condensation, the latter often having a very rapid action in dissolving rubber. This cleaning is accomplished by means of waste or cloth at the end of a stick. Where condensation is

encountered it is advisable by soaping to protect the bag as well as may be. Soap will also help in making a bag hold back gas where the inside of a main is quite rough. If it is thought desirable to use a bag saving device, this is now screwed on.

The bag fork, I, Fig. 10, is sometimes used in inserting the bag, which is placed in a folded position on the face of the fork, and the bag stem pulled back between the prongs near the hilt. The bag and fork are then entered simultaneously, the fork serving to force the bag down into the main and away from the hole. After inflation of the bag, the fork is withdrawn. Where there is much more pressure on one side of a bag than another, the fork is of special use in holding the bag in place until inflated. In the absence of a bag fork, a stick is used to force in the bag, which is always snugly rolled or folded.

A bag is properly placed when the axis, passing through the stem, coincides with the axis of the main. In inflating large bags, a bag pump, B, Fig. 18, is generally used. By means of a small bag inserted in the supply line, an indication is given of the degree of inflation of the bag in the main. This also can be told by observing the bag itself through the bag hole. Large bags have cocks attached to their stems to control the air flow. The stems of small bags are tied together in a kinked position. A small stick should be attached to the stems of all bags in such a way as to prevent the bag from being forced away from the bag hole. All bags or stoppers, while in use, should be under constant supervision to ensure that they are maintaining their inflation and position.

In removing a bag, the air is first allowed to escape, and then the bag is slowly pulled out through the opening, first, by means of the neck, and then by pulling on the bag itself, the pull being always applied close to the main, and the bag kept rolled up like an umbrella. All condensation should be immediately removed from the bag by the use of soap and warm water.

In inserting a stopper, A, Fig. 18, it is neatly folded and pressed together, and pushed in carefully and slowly, it, as well as the bag, being always a snug fit in the hole allowed by the schedule. The flexible frame and the handle are kept uppermost until the stopper is completely within the main. The top of the flexible frame is then in contact with the top of the main and a short distance back of the hole, the bottom of the

Fig. 18.—(A) Stopper, page 67. (B) Bag Pump, page 66.

frame is on the bottom of the main, and the axis of the top is at an angle of about 45° with the axis of the main. The stopper is now revolved through 180°, and pushed into the hole about as far as it will go, bringing the top of the frame a few inches from the hole. The top is kept in this position, or perhaps forced slightly away from the hole by means of the

short handle, while by the long handle the lower end is drawn forward towards the hole, thus bringing the plane of the frame into perpendicularity with the axis of the main, and forcing the frame into a circular shape. When ready to draw the stopper, the lower end is forced back along the bottom of the main, and the upper end is drawn slightly forward, until the frame has assumed its greatest possible length. The stopper is then revolved 180° bringing the frame on top, and withdrawn.

CARE IN REGARD TO SUPPLY OF GAS.

Bagging off the supply of gas involves certain operations which, unless precautions are taken, may result in a diminution, or entire stoppage, of supply to consumers. These operations are: First, the tapping of the bag hole and any subsequent opening of it, allowing free gas flow; and second, the insertion of the bag with a consequent interruption of gas flow in the main.

The precautions to be observed in connection with the tapping of the bag hole, of course, apply equally to the tapping of any hole for any purpose, or to any work which makes in any pipe conveying gas, an opening whose area is of appreciable size as compared with the area of the pipe. Experience has shown that if flow is quickly established through the ordinary hole tapped in the average size main, the diminution in pressure caused thereby, may be quite sufficient to put out lights turned low, and that the quick uncovering of the opening, causes the pressure in the main to fall momentarily to a point lower than is caused by the steady flow of gas through the opening. Of course, the amount of effect produced in any main, that is, the number of feet each side of the opening that the effect extends, and the extent of pressure lowering, depends entirely upon the relation between size of main and of opening, and the conditions affecting the supply of gas into the main. However, such serious results may ensue from unlighted gas issuing from burners, extinguished by a lowering of pressure, because of the careless tapping of holes and their uncovering in putting

in bags, that it is wise, especially in cities and large towns, to observe the following precautions.

When any opening is made between a main and the atmosphere, so that gas may escape from the opening, the plug, tap, or fitting, the removal of which makes the opening, should not be moved away from the main at right angles to it, but should be moved sidewise over the opening, and kept in close contact with the main, and as it is moved off the opening, the fitting, or plug, which is to take its place, should be moved on. Neither motion should be rapid or sudden. The result will be that at no time is the whole area of the opening exposed for the escape of gas, and also that there is no rapid change in the area through which gas is escaping.

When a hole has been tapped for the insertion of a bag (or stopper) and the bag is to be inserted at once, in removing the tap from the main, it should be slid sidewise over the hole and followed immediately by the hand, placed in such a position as to partially encircle the receding tap, and to block off the escaping gas as far as possible. In inserting the bag, the hand should be moved slowly over the hole to afford room to insert the end of the bag, and the hand should continue to cover the hole as much as possible, until the latter is filled by the bag. As the bag gets further in and begins to taper off towards the top, the hand should again be placed over the hole, and kept there until the bag is inflated. In withdrawing the bag, the same precautions should be observed in reverse order; and, in general, everything done which will decrease the absolute rapidity of gas flow, and the rapidity of change in amount of flow.

The practice described above should be followed in mains of all sizes. In addition, where the main is 3″ or smaller, or is supplied from only one end, and any portion of this sole supply is 3″ or smaller, a pressure gauge, as shown in Fig. 19, should be connected with the main so that any pressure drop can be noticed, and, if at any time as little as 1.0″ pressure is shown, then an examination must be made in the neighbor-

ing houses to make sure that no lights have been put out. In general, in any work involving possible interference with the evenness of gas flow, any nearby street lamp supplied from the main in question should be lighted, as its flame will be a valuable telltale of what is happening in the main.

Discussing now the second precaution, viz., what will be the effect of the insertion of the bag in that portion of the main which must not be deprived of gas, the whole question hinges upon what is *known* of the main connections in the region in which the work is being done. Where the records are perfect, and show that a main is connected at both ends, then in the absence of a stoppage, such as water in a trap, or a drip, or some other obstruction, a bag, or bags, may be inserted with confidence that the result will be the stoppage of supply to that section of main only, whose isolation is desired.

If, however, it is necessary to bag off a portion of a main which is not positively known to be supplied from both ends, the work should be done according to the following directions, as illustrated by Fig. 19. Place a bag (or stopper) through the hole at "X" in the position "A," Fig. 1, judging the flow of gas toward the bag by noting the speed of the gas escaping from the bag hole. The escape of gas thus permitted should be brought on gradually for reasons already explained. If no drop in pressure is noticed, deflate the bag, inflate in position "B" and test for flow of gas as before. If this test indicates a satisfactory flow, leave bag in position "B." Another bag inserted through bag hole "Y" in position "C" completes the operation of isolating the portion of the main to be repaired or removed. The tests at "X" have demonstrated that gas was being supplied in both directions, and that therefore no bypass is necessary.

If on making test with bag in position "A" or "B," a drop in pressure is noted, indicating some obstructions or a dead end, the bag should be left in position inflated until the extent of the section deprived of gas is ascertained and the meter cock in each house closed. (This same routine should be followed in

any case of bagging off a main where it was discovered that gas had been shut off from a section not meant to be isolated). Having done this, the bag may be deflated and gas again allowed to flow into the section unintentionally isolated. Before resuming the work necessitating the bagging, a siphon gauge, Fig. 2, should be attached to the section previously isolated and a by-pass laid around the section to be bagged off. Observations of the gauge should be made while insert-

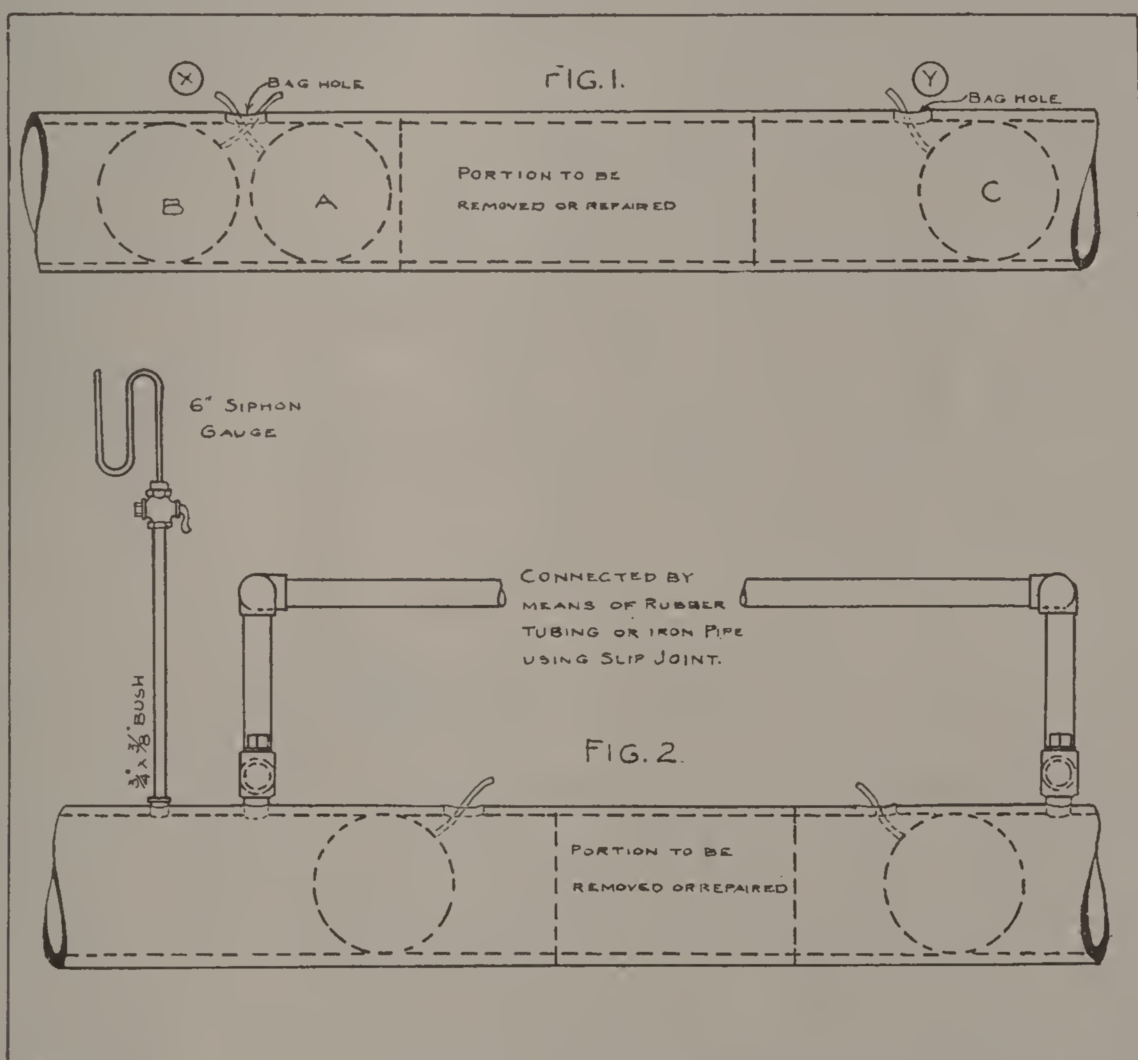


Fig. 19.—Pressure Gauge. Page 70.

ing or removing by-pass, bags, etc. If at any time the pressure falls below 1.0″, the gas should immediately be shut off the section so affected, and an examination made of each house as already described. Fig. 2 shows the position of the bags and by-pass when ready to cut out or repair under the conditions already described, in other words, the arrangement necessary when the main is fed from one end only.

When withdrawing the bags in the arrangement as shown in Fig. 1, on completion of the work, the bag (or bags), which was the first to be inflated, should be drawn first, and the resulting pressure noted. In this way, if by any chance the supply of gas has been unknowingly cut off on the side of the section first bagged off, this fact will at once be shown on withdrawing the bag, by the entire absence of pressure, and the proper precautions can be taken. When, as in Fig. 2, a by-pass is in use and in place, the first bag inserted should be at "L" in the dead end supplied by the by-pass, being placed as shown on the side of the hole away from the section to be repaired or removed. This bag must be the last one withdrawn, for the full supply of the main, in addition to the by-pass, must be available to the dead end section as the last bag is being deflated, or otherwise the escape through the hole "W," even with every care exerted, might be sufficient to render the supply through the by-pass insufficient to keep up the pressure in the dead end section.

PURGING.

The operation of "purging," *i. e.,* filling a main with gas, may be either very easy or very difficult, according as there happens to be a small length of main, or an extensive system to be dealt with. In every case, however, care is needed to prevent any chance of ignition of the explosive mixture of gas and air issuing from the main being purged.

In its simplest form as applied to a stretch of ordinary size main, ending in a location where a little gas smell is not objectionable, purging consists of removing a screw plug from a hole tapped in the main at the end farthest from the source of supply, and allowing first the air and then the mixture of gas and air to blow into the atmosphere until either by smell, or by sampling the issuing gas, it is believed, or found, that all the air has been removed. The advisability of sampling increases with the size of the main, and with the chance of the mixture of gas and air being supplied to consumers before any

other operations to produce a flow of gas through the main in question, and, therefore, to reduce the air to a negligible percentage.

The sampling may be accomplished by filling with the issuing gas a deflated rubber gas bag, and then removing the bag to a safe distance, inserting a pipe with a burner attached, in the stem of the bag, squeezing the bag and lighting the stream issuing through the burner. The color of the flame will indicate how nearly pure gas the bag contains.

With an increase in the size (and to some extent the length) of the main, will result an increased volume of gas and air to be discharged into the atmosphere, before purging is complete. This will often mean the advisability of a standpipe screwed into the outlet hole, and discharging above the heads of pedestrians. Also, as the period in which an explosive mixture exists, is longer, than with a small main, the use of wire gauze in the standpipe is a wise precaution. This gauze prevents any flame which might ignite at the standpipe end, from flashing back into the main.

In every case of purging, the precautions already spoken of under "Care in Regard to Supply of Gas," should be carefully observed. After the main is considered to be properly purged, the plugs of all drip standpipes should be removed, to allow the escape of any air that might be pocketed in the lower portions 16″ and over, is shown in Fig. 20. The convenient method for sampling the gas will be noted.

Very rarely it may happen that the main to be purged is situated where the escape of gas would create a considerable nuisance, as in a crowded business thoroughfare. If so, if it is not advisable to purge until the smell comes and then stop, trusting to the sufficient admixture of the air remaining with the gas, to prevent any chance of lights going out, or of very poor illumination, the only remaining course is to burn the issuing stream at the top of the standpipe. With a gauge of mesh as small as that used in safety lamps, and a standpipe

equipped with four successive sheets of gauze, arranged in two of the drip pots.

An arrangement that has been used in Philadelphia on mains

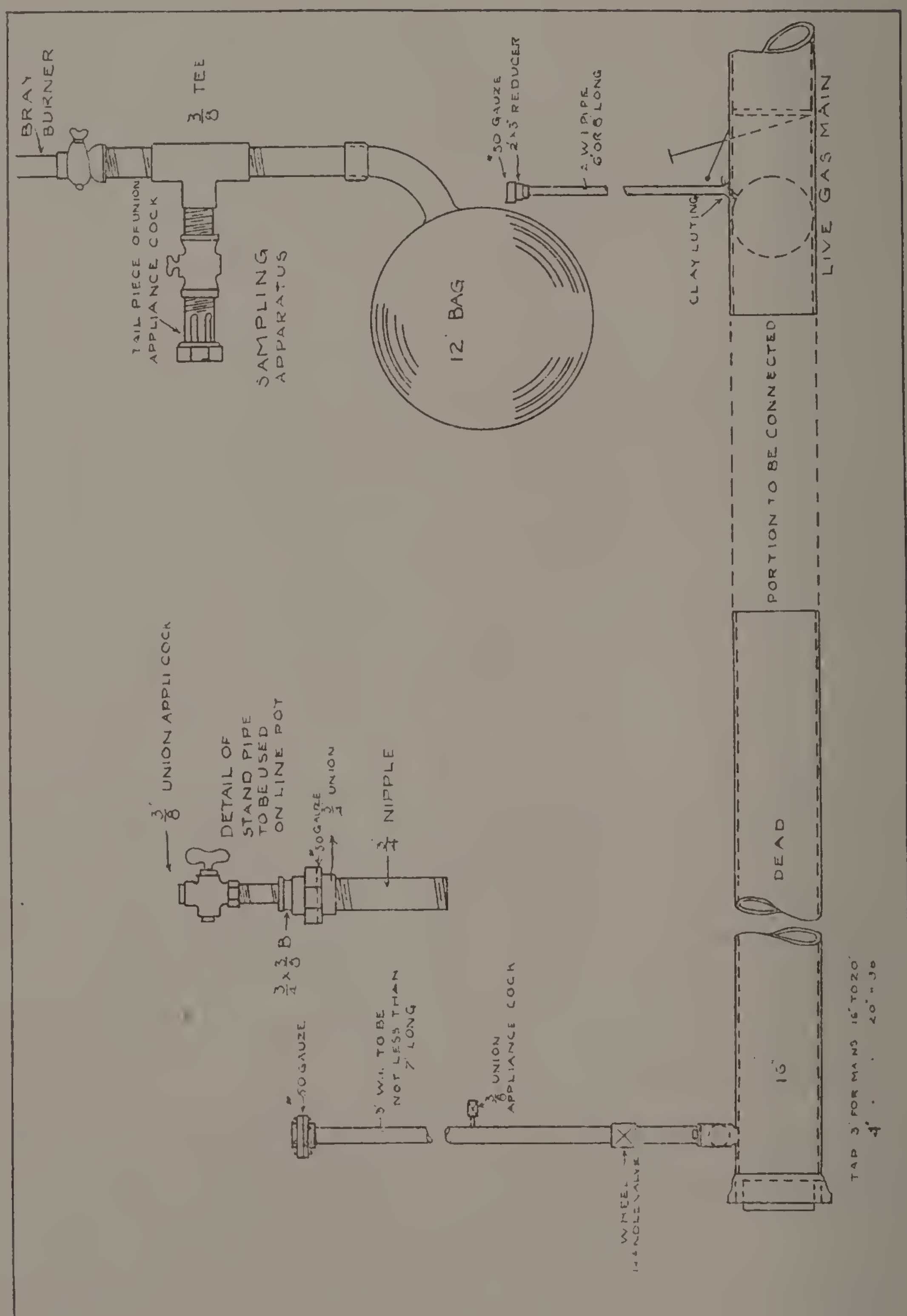


Fig. 20.—Method of Purging Large Mains. Page 73.

pairs, two feet apart, each sheet of a pair being separated by a ½″ gasket, there would seem to be no risk of any flashing back in the main, if care is taken to observe that the pipe is not becoming warm, for a reason now to be told.

In supplying New York City with gas made on Long Island, it happened that fifty miles of mains were laid before the tunnel under the East River was completed. Therefore, this main system had to be purged more or less as a whole, and it was actually purged in two sections. It was decided to burn the gas in order to be sure that all of the air had been expelled. Standpipes with four gauzes about as described above, were successfully used on this occasion and also on each subsequent addition to the main system, until one day, when purging about one thousand feet of 20″ main, an explosion occurred, due undoubtedly to the flame at the end of the standpipe flashing back into the main. The only explanation for the passage of the flame back through the four sheets of gauze, would seem to be that the flame first flashed back to the upper pair of gauzes, and burned above them so long as to make them red hot. In this case the flame would travel down to the second pair, and after they had become red hot, an explosion could occur if the mixture was still explosive. An observation of the temperature of the standpipe would have disclosed the fact of the flame burning on the gauzes, and the danger being incurred.

A feature of purging where more than a single line of main is in question, is the necessity for bagging at certain points to prevent large pockets of air. For instance, when one or more of the mains is fed from both ends, three bag holes, with a bag in the centre hole, will allow the air to come both ways to the bag, and issue out of the other two holes without forming any pocket. Naturally, in work of this kind, the tightness of the bags is very important, and each such bagging place should be under the continuous surveillance of a reliable workman.

MAINTENANCE OF GAS SUPPLY DURING MAIN LAYING.

IMPORTANCE OF MAINTAINING SUPPLY.

So far, in discussing the question of main laying, it has been assumed that the work involved an extension into new

territory. Many mains are laid, however, to replace existing lines, and in these days of the extensive use of gas for heating and other domestic and industrial purposes, it is often imperative, with any due regard for the rights of the consumer, that any cessation in gas supply be as short as possible. This means to begin with, that gas supply be kept up either through the existing main or temporary main, until the new main has been purged. If gas is maintained in the existing main, but this must be disconnected from its ordinary source of supply; to allow the connection of the new main, then a by-pass must first be installed across the gap. It also means that the transfer of old service to new main, or from old main and old service to new main and new service, should be done expeditiously.

In considering this work, three different conditions will be taken up in turn: First, where the existing main is not in the way of the new one, and therefore can be kept in use until the main has been purged; second, where the existing main must be removed to make way for the new one, but prior to such removal a temporary main may be laid; and third, where the existing main must be removed, but no temporary main is feasible.

SUPPLY BY EXISTING MAIN.

Where the existing main, whether or not exposed in the trench made for the new main, may continue to supply gas until the new main has been purged, the work of main laying is not much more different than in the case of new extension, except for what support may have to be provided for any section of the existing main that may be exposed in the trench. At this point, it should be stated that the value of the iron recovered, even at scrap prices, generally makes it an economical proceeding, other considerations being equal, to lay the new main in such a location that the existing main may be removed with either no, or only a slight amount of additional excavation.

Before the new main is purged, all necessary service holes

should be tapped, and service renewals made to within the cellar wall. Then in the case of a consumer whose service was renewed, the discontinuance of gas supply, will only cover the time necessary to transfer the piping on the inlet side of the meter, from the old service to the new one, which may involve only the unscrewing of the existing inlet connection, and the screwing of a new inlet connection attached to the new service. When the service does not need renewing, there will be necessary, in addition to the work inside the cellar and preceding it, the cutting of the existing service and its reconnection to the new main. The above service details apply equally as well to the paragraphs that follow.

SUPPLY BY TEMPORARY MAIN.

Where a temporary main is to be laid, its size should be determined from accurate knowledge of the maximum demand of the consumers to be supplied. Usually a 2″ or 3″ main will be amply large, and wrought iron is generally preferable for any size smaller than 8″. The location is normally above ground and close to the curb, either in roadway or on footway. Tees forming part of the line of pipe, make the best method of service connection. Each tee is joined by iron pipe, or by pipe and armored rubber hose to one of the existing services. This involves a cessation of gas supply while the service is being cut off from the existing main and connected to the temporary main. Generally, the connection to the service will be made outside of the curb cock, but even in that case, it will be advisable, when using hose connection, to put a cock between the hose and the outlet from the temporary main. This second cock allows a quick shut-off in case the hose connection pulls off or in any way develops a leak not capable of quick repair.

The temporary main will usually be supplied with gas through one (or preferably two) connections tapped into the existing main system. In the case now under consideration, viz., where a temporary main is used only during the laying of a new main, it is seldom necessary to make any provisions for

condensation in the trap formed by the service connection above described. Where, however, temporary mains are laid because of the forced removal of permanent mains during the progress of street work, and temporary supply will continue

Fig. 21.—Temporary Main. Page 78.

during cold weather, ample drip provision should be made at any trap.

Figs. 21 and 22 illustrate some features of temporary main work.

SUPPLY IN ABSENCE OF ANY MAIN.

The case in which the existing main must be removed to allow room for the new main, no temporary main was possible, and consumers were using gas at all hours of the day, would undoubtedly prove to be very rare. Where the existing main was fed from two directions, it could be cut out at the end from which the new main was being laid without installing a by-pass. Then the problem of main laying would

consist in removing the existing main in as small units as seemed practicable, and in purging the new main in small

Fig. 22.—Temporary Main. Page 78.

sections as laid. Holes for services would be tapped in the new main before laying, and would serve as successive purging and bag holes. In this way, no consumer need be out of gas

more than one or two hours, and by special expedients this time could be greatly reduced. For instance, a temporary pipe might be run from the top of the street tee in the last service on the new main, to connect with the service, or services, being disconnected from the section of existing main just taken out to make way for the next section of new main.

Where the existing main was only fed from one end, and this was the end from which the new main was laid, a by-pass would, of course, have to be installed to feed the existing main, and with the progress of the new main, the position of the by-pass would be continually changing.

REFILLING.

GENERAL CONSIDERATIONS.

In refilling, there is always an opportunity of skimping work, entirely absent in the case of trenching. The great saving in labor afforded by loose filling or puddling, as compared with tamping and ramming, often results in the adoption of one or the other, where not only the best interests of the work, but also of the public, require that ramming should be done. In discussing the conditions that should be kept in mind in deciding on any particular method, this general rule should never be forgotten, viz., that the public has a right to expect such refilling as will restore as promptly as possible to its original condition, the surface of any trench in any roadway, where traffic is seriously incommoded until such restoration is complete.

Unless the expense is very great, only good soil should be in close proximity to a main, and cover it by a layer six inches to a foot thick. This is especially important where the main is of wrought iron or steel and the good soil is substituted for ashes, cinders or city refuse. Cast iron is not nearly so subject to corrosion, but still good soil around it is advisable. The objection to refilling with small or large stones or broken rock, hinges entirely on the question of future repairs. If the trench is not apt to be opened to any great extent, as would be true

of most small main jobs, a large expense for soil to replace the excavated rock would not be justified. However, it often happens when solid rock is encountered, that the excavated material can be sold on the trench side at a slight profit, thus paying for the substituted earth.

During the winter time when the excavated earth freezes, it should be broken up as far as feasible, both as excavated and after being frozen, before refilling, because the larger the lumps replaced, the less the material returned to the trench, and the more settlement occurring after the frost goes out. As far as possible, unfrozen material from the centre of the pile should be placed around the pipe. When other conditions are acceptable, and the temperature is not so low that the water will freeze, instead of thawing the frozen lumps, puddling may be used to advantage with frozen material.

The character of the temporary surface over the trench in those cases where repaving does not follow immediately upon refilling, will vary with the kind of paving and will be discussed under the head of "Repaving."

RAMMING.

Ramming should be the practice wherever there is much travel along and over the trench, or where repaving must follow immediately. It is accomplished by tamping and ramming solely, or in combination with puddling.

If the main has been laid with cement joints, dirt has been tamped under and along side of, and rammed on top of, the pipe a depth of several inches, except at the bell holes. If lead has been used, the amount of refill that has been done prior to the completion of laying work, will depend upon the necessity for strengthening the trench or keeping the laborers busy. In any case the first refilling work after the pipe has been laid, tested and purged, is to cover any existing uncovered portion of pipe, and where compact filling is necessary, there should be for every shoveler on the bank two men in the trench, tamping the earth under the pipe and between it and

the trench sides, and then after the pipe has been covered, or a sufficient width of trench reached, changing to a rammer. When first tamping around a pipe, which is not held in position by any earth, the tampers should be in pairs, one on each side of the pipe, working against each other and thus preserving the alignment. Both in tamping and ramming, the lowest point on the trench should be refilled first, and the refilling thereafter carried on in horizontal planes.

For any mains larger than 12″, an economic width of trench for all laying purposes, will not afford room enough on each side of the pipe to ensure that the space between the bottom of main and of trench is filled even loosely, and therefore, unless there is a willingness to incur extra excavating expense, it must be understood that there will be under all large mains a space of varying dimensions, which will afford a gas leak a fairly free passage. However, this is about all the harm done, with the resulting chance of making the exact location of a future leak somewhat harder. If the main is properly blocked, it will not settle, and if the trench is elsewhere properly filled, the hollow under the main will cause no earth settlement. Nevertheless, because it is impossible to entirely fill the space under the main, does not mean that no effort should be made to fill as much space as tools and trench will allow. The larger the main, the more attention should be paid to this first tamping, and the better the laborers assigned to the work.

With a proper proportion of rammers to shovelers and the right kind of rammers, which mean men able to and paid to ram *hard,* there will usually be no difficulty in replacing all material removed for mains 8″ and smaller. On larger mains, where earth has to be hauled away, an accurate account should be kept of such removed material, and if it exceeds the volume of the pipe laid, an explanation should be forthcoming from the foreman.

In recent years power rammers, driven by gasolene or compressed air have become available. They are probably still in an experimental stage, but with the increasing difficulty of pro-

curing good labor, the value of such machines, both as labor saving devices and as ensuring proper ramming, will increase.

In any refilling, but especially in ramming, care is necessary to protect from injury, all small pipes exposed in the trench, especially any lead water services. These, where over the pipe, should be blocked from it, or if under, from the trench bottom. In either case the blocking tends to prevent any pressure of the earth on the lead pipe, pulling it out of the water main. Ramming over terra cotta pipe should be carefully done to prevent a smashing in and possible stoppage.

If the trench is to be paved at once, refilling should stop at the point below the surface where the paving base begins. Otherwise, the trench should be filled to the street surface, or at the most, only slightly mounded. If it should happen for any reason that material is lacking, enough should be procured to leave the trench surface flush with the rest of the roadway.

Occasionally in trenching, it is advisable, or necessary, to tunnel under certain paving or structures. These tunnels usually exist in connection with trenches refilled by ramming or puddling. Ordinarilly it is more economical to break down the tunnel roof, than to refill from the sides. Of course, where structures such as street railroad tracks, with concrete road bed, are concerned, breaking down is *not* the right course.

PUDDLING.

Puddling appeals to every foreman because of its cheapness, and should be practiced wherever the conditions are favorable, viz., where the soil is of the right kind, and there is no danger of water soaking into cellars, or undermining the pipe. Puddling in a street made of filled in material, may cause a general sinking of the street surface. In built up sections, puddling may be objectionable because of the chance of water getting into cable conduits, or because of the inability to pave at once upon the puddled material.

When puddling has been decided on, the pipe should be covered at least six inches by well rammed earth before any water is let in. Also, if the trench has over 5 per cent. grade,

the first ramming should reduce the grade to this figure, in order to prevent any wash under the pipe by water sinking through the loose fill. Dams at frequent intervals will also serve to prevent any scouring out by water flowing down a grade, and in any case, dams would be necessary to confine the water to each terrace made by the first ramming.

The preliminary ramming being done, the trench is filled to about one foot of the surface, and then water turned in. Usually the water is obtained from the nearest fire hydrant, hydrant keys being furnished by the municipal authorities, often on payment of an annual fee. Care should always be taken to avoid injury to paving by the flow of water over it. As the water flows along the ditch, bars are hand driven through the loose material into the rammed earth alongside the pipe. As the bars are driven down, they are swung around in a circular direction, and the funnel shaped holes so made allow much water to soak into the earth around the pipe and perhaps carry earth to fill any voids under the pipe, but there is no chance for a flow of water rapid enough to affect the stability of the pipe. As the earth sinks under the action of the water, more earth is added, especially when needed to preserve any desired channel for water flow, which is not stopped until the earth is well saturated and water runs over it without being absorbed. Then the remainder of the earth is thrown in and lightly rammed into a slight mound over the trench surface. Too much ramming is to be avoided, as it tends to produce a spongy condition. Too much water is also to be avoided, as tending to soften the bed of the trench, causing the pipe to settle and to make the refilled material so soggy as to delay repaving. Ordinary labor cannot be trusted unwatched on work of this nature.

The method above described is considered preferable to the practice sometimes followed of throwing in all the earth and digging a trench in the centre of the mound for the water to follow. Such a procedure leaves no dry earth to finish off the trench.

Where services are laid in connection with the main work, especial care should be given to the repair of the opening made in the house wall, if there is to be puddling and the water line will be higher than the service opening. Of course, the more porous the soil, the more reason for a good cement coating, both on outside and inside of wall. Also, a dam of dirt should be thrown across every service trench at its junction with the main trench.

LOOSE FILLING.

Naturally the largest amount of main work will consist in extensions to the existing system, made necessary by new buildings and usually such extensions are laid in unpaved streets. With the ordinary size main and an interval of some months elapsing between laying and paving, there can be no objection to loose refilling of the trench, leaving to time and street traffic the gradual consolidation of the refill. In such unpaved streets there are always many trenches beside those made for gas purposes, and the roller used by the paving company is relied on to compact the entire road-bed.

The surface of this trench after a loose refill is that of a mound perhaps a foot high. This serves as a warning to wagons to keep away. It is incumbent on the gas company to make a frequent enough inspection of the trench to ensure the prompt filling of any dangerous holes that may be formed after a hard rain. Also, a certain amount of trimming of the mounded earth may be required from time to time.

CLEANING UP.

The final cleaning up after any main laying job can only take place when repaving is complete, but as in many cases the repaving is done by a contractor; such cleaning up as may be done before repaving and by the company's employees, will be treated of now.

Almost any one can open trench and obstruct and dirty a street and footway. Few contractors on street work ever clean up properly. All gas companies should see to it that

the natural disgust induced in the occupants of any street at seeing it torn up is followed as quickly as possible by a feeling of satisfaction at the prompt execution of the work and the thorough restoration to conditions previously existing. A broom and sufficient buckets of water are aides not often enough used in the final stages, but they are generally needed to do justice to the occupants' property in the removal of all earth stains on the house fronts, side walks, tree trunks and boxes, grass, etc.

In this connection, good planning of a job to be sure the difficult portions are not neglected, will do wonders to make the work move along continuously and not leave any gaps remaining open for days after the work on each side is finished.

REPAVING.

GENERAL CONSIDERATIONS.

It is not considered advisable to describe the art of paving, and this not only because it would add to the length of a treatise already very long, but also because many companies find it advisable to contract their paving. This tendency is increased by the growing prevalence of asphalt, the restoration of which by the company is out of the question. In the old days when cobble and rubble were alone met with, a few paving tools and a little sand were the only equipment needed to enable every main and service gang to restore their own paving. So far only roadway paving has been in mind. A like change has occurred in the footway. Cement has given place to bricks, and again the new form requires more skill and equipment in its restoration than did the old. Therefore, as has been said before, the tendency is to contract out the paving. This involves more lamping of trenches, rather more office work in connection with paving bills, and possibly more inspection of paving work, though with reliable contractors their work need not require any more attention and inspection than would company paving. By inspection, two results are obtained: No poor work is allowed to remain, as an annoy-

ance to the public and a bad advertisement for the company, and no dangerous holes may exist long without detection. As the details of an inspection system will vary greatly according to local conditions, no description of one will be given here.

ASPHALT.

If the street is a much travelled one, it is advisable to leave the trench in such shape that it may be driven over during the interval between refilling and repaving. This condition has an added advantage that it dispenses with the expense of lamping the trench. When the material has practically all gone back, the concrete of the base (if any) should be thrown in on top of the earth, and then the asphalt pieces laid down. If the pieces have been well cut, a very good job can be made. In some cases of service trenches on important streets, with extra care in cutting the asphalt, and the use of a little cement in the cracks between the pieces, a very fine temporary job results. Again, the base material may be left along the trench or at the curb in piles and just the asphalt laid back, or the asphalt may be left piled up and the trench surface finished off with the base materials. In most cases, however, it is probably true that the surface of a long trench cannot economically be made safe for bicycles or motor cycles, and if there is much of such traffic, it would be necessary to lamp the trench until repaving.

In order to ensure prompt repaving, it is advisable to provide in the contract for decreased prices for all delayed work. For instance, if paving is supposed to be laid within four days of receipt of notice, seven-eighths price might be paid for paving laid five days after notice, three-quarters price six days, etc. Also, the use of concrete base under all asphalt, whether the original paving had such base or not, will result in a gratifying absence of settlement, a condition always glaringly apparent in asphalt.

In towns without any asphalt plant it will generally be satisfactory to the municipal authorities to substitute a cement

finish on a concrete base for any asphalt torn up, this being regarded as temporary repaving only, and being replaced on the first occasion that asphalt material is available.

CONCRETE BASE PAVING.

Most modern street paving is laid on a concrete base, and the tendency of this class of paving, as with asphalt, is to intrust its restoration to a contractor. Usually the more or less broken masses of concrete form the surface of the trench as left by the rolling gang. Whether such a trench will need lamping or not until repaved will depend on its location, the compactness of its top surface, the amount and character of traffic, etc.

ALL OTHER PAVING.

Under this head falls vitrified brick, belgian block, cobble and rubble, all on sand base. Where small openings only are made in such paving, there are many arguments in favor of its restoration by the same gang that did the opening. In other words, on detached service or lead work, the ability of the gang to do its own paving will save all lamping cost, as well as a certain constant expense entailed by unpaved trenches, such as water in cellars. Also, it is possible to get better paving done by the company's men than by the contractor's. When opening in a street requiring sand between the paving stones, one of the obligations of a gas company, in order to ensure a good job, is to see that such sand is actually brushed in between the stones and not left on top to be a nuisance on windy days.

As a rule, however, the fact that much of the paving is better contracted for, will incline the average company to contract for all. In doing so a bigger profit is often paid to the contractor than is realized, until it is found by experience how cheaply, with proper organization, sand base (and even concrete base, if there is enough of it) paving can be done.

Below is given some information as to equipment useful in paving work:

PAVING SMALL OPENINGS AROUND STOP BOXES, ETC.

1 Light push cart similar to a plumber's push cart, containing:

1 Spoon bar
1 Street broom
1 Small galvanized bucket
1 6″ Cold chisel
1 Stop box cleaner
1 Brick hammer
1 Caulking hammer
1 Pick
1 Sharp nose D-handle shovel
1 6″ Trowel
Cement, sand and bricks

PAVING SERVICE AND SMALL MAIN OPENINGS.

1 One-horse open body spring wagon, with a small top over the seat for the protection of the men, containing:

2 Street bars
1 3′x4′ Mixing board
1 Street broom
1 Dust brush
1 Galvanized bucket
2 Cold chisels
1 Paver's straight edge
1 Curb or radius edger
1 Wooden float
2 Brick hammers
1 Caulking hammer
1 Concrete knife
2 Picks and handles
1 Pitchen tool
2 Diamond points
1 Rake
1 Belgian block or paving rammer
1 Dirt rammer
1 Dot roller for cement
1 Seamer
1 Flat nose D-handle shovel
1 Sharp nose D-handle shovel
1 Sieve
1 Finishing trowel
1 4″ Trowel
1 8″ Trowel
1 Monkey wrench
Paving supplies such as cement, brick and crushed stone, etc.

This equipment is sufficient to do, on a small scale, all kinds of paving except asphalt.

PAVING LARGE MAIN OPENINGS.

For extensive paving the number of tools listed just above is increased depending upon the amount of paving to be done.

RECORDING.

REASONS FOR RECORDS.

A knowledge of the number of feet of each size of pipe comprising the street main system is valuable at all times, and very necessary when a valuation of the mains is required.

This knowledge, subject to varying degrees of error, is possessed by every company, and almost always presupposes the possession of a map showing the location of the mains by sizes. In many cases, however, not only is there great uncertainty as to the correctness of the sizes shown, but also the location as measured from the property or the curb line, is either wanting or incorrect. This lack of proper records is often the natural consequence of the fact that in the beginning the location and size of every main was easily a matter of memory for the few employees. As the system grew and new employees succeeded the old, there was failure to transfer records from brains to paper. Another reason for lack of records, or improper ones, is carelessness in past years in preserving and entering the information furnished when the main was laid.

At present the necessity for proper street main records is thoroughly appreciated, and the problem has been solved in many different ways, depending upon differences in local conditions and in the human equation. In what follows, will be found a description of methods of which experience has proven the worth.

SYSTEM OF RECORDS FOR NEW MAINS.

In determining the character of requisite street main records the usual condition is that of a main system sadly lacking in data regarding existing mains, and therefore needing records of maintenance as well as extension work. Before considering this condition, the rarer one will be considered, where an entirely new main system is being installed either for a competing company, or for the first company in any locality.

FIELD RECORDS.

For the field record, that is, the one taken out on the work, a Transit Book is very convenient. This is 4½″ x 7⅛″, has about sixty leaves, and is ruled with horizontal and vertical lines. In making the records, a zero point may be taken at the beginning of the line, and all locations along the line given

with reference to this zero. For long lines, especially in country roads, this is the best way, and it is also very convenient in city streets. Following this method, once the proposed line of a main has been measured over, and the position of all desired points of reference noted, any portion of the main as laid can be quickly shown on the record, no matter whether gaps occur or not.

The amount of record that will be needed to enable the main to be properly located on a map, and also easily found where occasion requires uncovering, will depend entirely upon the number of changes occurring in depth and alignment. The depth to top of pipe and the distance out from the curb, or property line, should be given every one hundred feet when there is no change, and where the dimension is changing, at enough points to define the line. A single line will suffice to show the pipe. All special castings, whether branches or bends, should be accurately located, the length of each special being considered to be the distance between the faces of its bells, where it has two bell ends, or between the bell of adjoining pipe or specials, when the special being measured has two spigot ends, or between the bell of the special and the bell of the adjoining pipe or special, where the special being measured has one bell and one spigot end. A bracket mark, "]," at right angles to the length of the pipe is an easy way of representing the face of every bell, the horizontal lines extending away from the face of the bell.

When the points of reference along the main, such as dividing property lines, intersecting roads or streets, etc., are not at right angles to the main, these points should be located by their intersection with whatever line is being used as a base to measure distances at right angles to the main; and not by their intersection with the main itself.

With all specials thus located at the proper distance from the assumed zero point, the amount of straight pipe laid at any moment, may be easily calculated, and in some cases, this is an easier way of getting it than by adding up a series of

figures showing the work day by day. Any portion of the line, where the depth is changing rapidly, or where the pipe is not parallel to the reference line, must be measured along the pipe itself, and such measurement recorded and used, instead of the distance as measured on the reference line between the stations marking the beginning and end of such deviations in line and depth.

When there are many specials in close proximity, which usually means many changes in depth and alignment, the scale sufficing for the ordinary portions of the line will prove too small. Therefore, either the scale ought to be increased at these points to give a proper sketch, or else a detail sketch on a larger scale should be shown elsewhere.

While, as a rule, the depths would indicate which way the line was dripping, at the same time it is surer and much more convenient for purposes of permanent record, to indicate the direction of drippage by an arrow, parallel to the line and pointing with the flow.

A record of other structures encountered is generally of sufficient value to warrant the slight extra work so involved. This record of foreign structures increases in value as underground conditions become more congested, and when there is another gas company, whose records are probably not very complete, any records of its mains are apt to prove very useful, either in competition or consolidation. Where the foreign structures are mains, they can be indicated in the same way as the main being laid, though probably not in so much detail Where they are conduits, and therefore almost invariably rectangular in section, a line may be drawn indicating the nearest upper edge to the main being laid. This, in connection with the distance from the centre of the main, the breadth and depth of the conduit, and depth of its top surface below the street level, locates it completely.

It is of value to indicate on the record the date on which each foot of main is laid. This is very easily done by placing the date of each day's work between arrow heads, located at

the proper points. Where, for any reason, the work is quite discontinuous, this graphical record of dates may prove quite

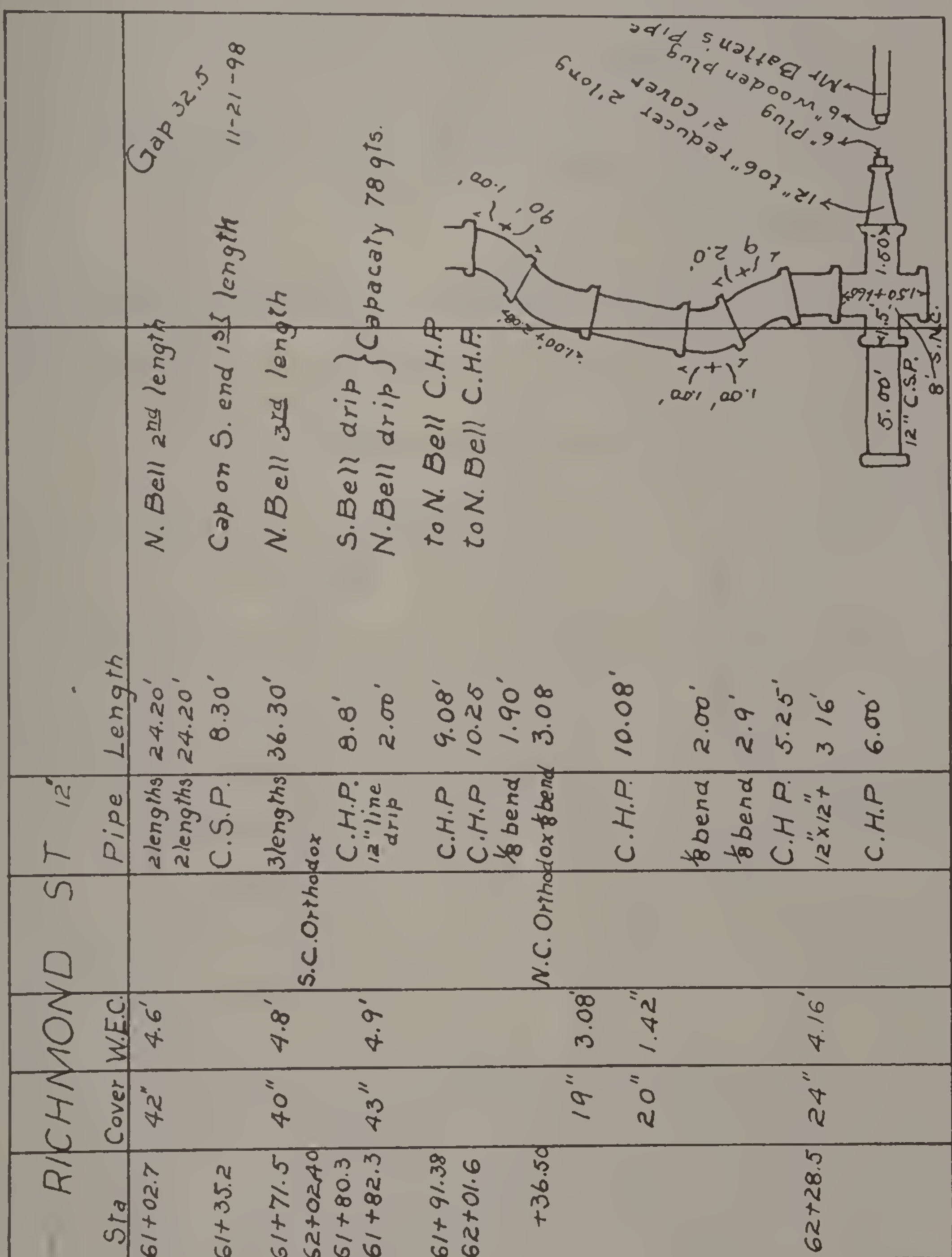


Fig. 23.—Transit Book. Page 93.

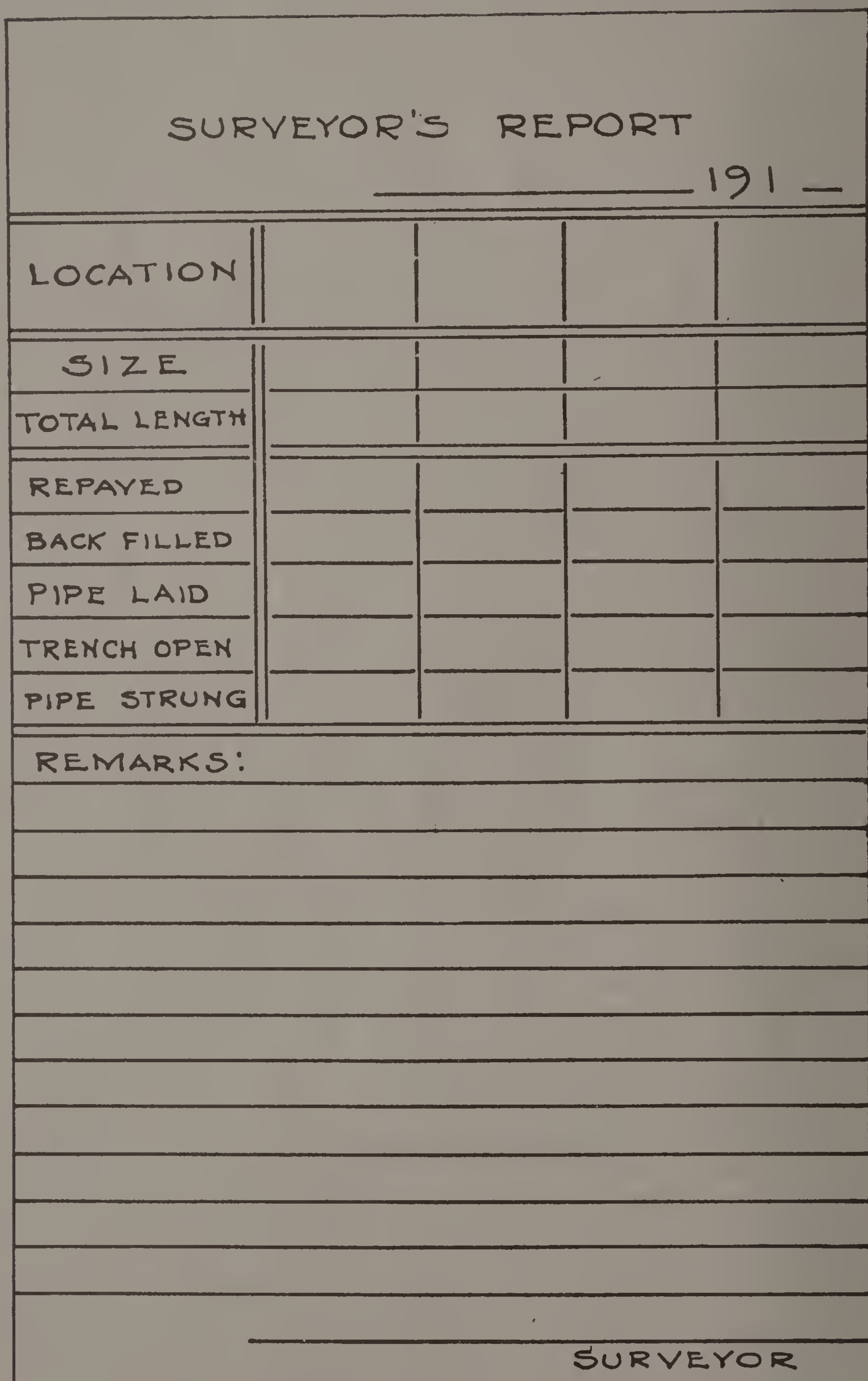
valuable as a history of progress and of work condition from day to day.

Fig. 23 shows several pages of a Transit Book with a record made out according to the ideas above given.

REPORTS TO OFFICE.

Where the company is a small one no work progress report to the office is needed, as the information can be obtained by

an inspection of the field book, or is a matter of personal



SURVEYOR'S REPORT

_____________ 191 _

LOCATION				
SIZE				
TOTAL LENGTH				
REPAYED				
BACK FILLED				
PIPE LAID				
TRENCH OPEN				
PIPE STRUNG				

REMARKS:

_____________ SURVEYOR

Fig. 24.—Postal Card Progress Report. Page 95.

knowledge with the main foreman. When these conditions no

longer obtain, and a daily or weekly report is needed, a form as shown in Fig. 24, should be used, printed on a postal card where mailing is necessary. "Repaved" shows the total number of feet repaved to date; "Back Filled," what has been filled but not repaved; "Pipe Laid," the amount of pipe laid where trench has not been refilled; "Trench Open," the amount open in which pipe is not yet laid; "Pipe Strung," the number of feet of pipe delivered on the work and not yet laid. This information is particularly valuable in the case of a long line, and gives the office a clear idea of what the physical condition of the work is at the time of report.

PERMANENT RECORDS.

The best form of permanent records for the conditions we have been considering all along, viz., an entirely new system, will depend somewhat upon the maps and their scale that are available for the streets occupied. For all large and many small cities, atlases may generally be obtained with plates whose scale varies from 200 to 500 feet to the inch. There are very few small towns for which maps are not obtainable, and in the country there are usually the maps of the Geological Survey to fall back on. No company should make up its own map except as a last resort, for map work easily runs into great expense.

On the map a line will indicate by its color the size and general location of a main, but the scale will be too small to make it advisable to indicate specials, drips or any details of line. To get such details, a different set of records is wanted, except indeed in companies selling say less than fifty millions a year, in which the original field book record will, with the map, supply all necessary information. When the field book is used, the map should indicate field book number and page containing the record of every block, or say 500-foot section of main. In this way an inspection of the map shows at once where to go for the detailed record.

When the field book information is transcribed, the desirable

unit for the new detailed record is either the city block, or for country roads for lines under 1,000 feet, the total length of main, and for lines over 1,000 feet, some fixed distance, such as 500 feet. The material used for the record should be something like tracing cloth, or thin bond paper, from which blue prints may be made to form the working file, while the originals themselves are kept in a fire-proof safe. Each sheet should be about 7″ x 18″, and should give the main in plan and in elevation, and be a faithful transcript of the field record in every point necessary to give a proper idea of the location of the pipe and of other structures encountered. The drawing need not be to scale, and in this way speed may be gained and more space given to points on the line where many specials were used. Each sheet should be numbered and the various sheets numerically arranged in groups of one hundred. The general map, or maps, would in this case bear the proper record numbers opposite each block, or unit distance. Thus, to find any detailed record, it would only be necessary to look at the map, see the block number, and turn to the proper group of detailed records, where in its numerical order would be found the record desired.

When there is much occasion to refer to the detailed main records, the above system is exceptionally valuable, because of the quickness with which the records may be found. Where, for any reason, such as for instance to locate a main for a service gang, it is necessary to send a record on the street, a convenient way is to make a rough free hand sketch on a white scratch pad, 5½″ x 8½″, in triplicate, by means of carbon paper, of the location wanted, give all three the number of the record from which taken, send one sketch on the street, and file the other two numerically. The service man should be instructed to return the sketch, and no other sketch need ever be made for that particular location, until all three are lost, or worn out.

Where the record may be needed on the street by the main foreman, there is, of course, no reason why the proper blue

print should not go out, but for service work the sketch system is preferable.

SYSTEM OF RECORDS FOR NEW AND EXISTING MAINS.

SMALL COMPANY.

Coming now to the condition that confronts the average distribution man, viz., a main system that is being enlarged every year, and that is also lacking in proper records of many existing mains, two systems of records could be used, one for the new mains along the plan already described, and another system for the old mains, the exact location of which is unknown. Where the company is selling less than fifty millions annually, which means a small town with few underground structures and few specials in the main system, one of the most convenient and easy ways to record information of old mains, as obtained from time to time, and to collect this information in a convenient shape, from which to make a graphical record later on, is by the use of the book, of which a specimen page is shown in Fig. 25.

The book was written up for every street on which mains were known to be, and distances shown between each intersecting street. As illustrated "O" is the east fence line of Erie, and "202" the east fence line of Huron, which is also taken as "O" for distances in the next block. One line of the book was allowed for every 25 feet, and any work done on a main, or information gathered by uncovering it, was entered on the proper line according to the location. Of course, if there were to be many openings, this book record would not provide adequate space, and therefore it is only recommended under the conditions already described. As will be noted, it also affords an opportunity for recording leaks.

To record the new mains of the small company just considered, the field book record, as described on page 96, with no transcribing, would be very adequate.

LARGE COMPANY.

The larger the mileage of mains, the more argument there

3 INCH MAIN			HIGH ST.						NORTH SIDE
LOCATION	MAIN LINE		DESCRIPTION OF BRANCHES.	BRANCHES		LEAKS.			REMARKS
	FENCE	DEPTH		FENCE	DEPTH	LOCATION	NATURE	DATE	
EAST FENCE LINE ERIE									
50									
						62'-7" 21'-6"	LEAKY BELL	6-26-96	PIPE SEEMS IN GOOD CONDITION
100	21'-11"	4'-1"							
112'-8"				21'-10"	4'-3"				
150'									
162'									
WEST FENCE LINE HURON									
202'-0"									
EAST FENCE LINE HURON									

Fig. 25.—Main Record Book. Page 97.

probably is for the use of one system of records, for both new

and old mains, although where, as is very often the case, the greatest amount of new mains are laid in one or two comparatively restricted areas on the outskirts of a growing city, there would be no confusion resulting in one system of records for these new mains, and another system for all others. Going still further, it is quite feasible to lay all new mains according to the field book system, and by means of the number on the general main map, it could be told at once where to look for any particular record. The presence of a number opposite the block, for which the record was desired, would indicate that such record was made according to the field book system, and would be found as a blue print in the pile(or file) indicated by its number. The absence of a number would indicate that the record was on a sketch card (to be explained later on) and would be found in the proper alphabetical file.

The great value of the blue print record lies in its presenting a continuous record of the main, but it does not lend itself to changing conditions, and this is one of the greatest objections to using it in large cities, where, apparently for many years to come, the installation of various underground structures, especially wire conduits with their attendant manholes, will cause many changes in main locations. To meet these conditions, the system of records used in Philadelphia, alike for new and for old mains, has proven very successful. Before describing it, a general account of the Philadelphia organization for obtaining records is advisable.

SYSTEM OF RECORDS IN PHILADELPHIA.

ORGANIZATION.

There is a Superintendent of Records reporting directly to the Engineer of Distribution. Under him is a Chief Draftsman in direct charge of obtaining, mapping and filing records, through the agency of street clerks and draftsmen. A street clerk is usually a graduate of a technical college or institute. Upon employment he is first put to work in the Records Division to familiarize himself with the system of records, one

of his duties being the duplicating of records. After this inside apprenticeship, he is sent out to record the work of one or more street main gangs. In this position he is able to learn all the details of street work, and to qualify for the position of foreman in charge of main or service work. The position of street clerk, besides serving as a training school for future foremen, superintendents and managers, allows the gang foreman to devote his entire time to directing his men. When the foreman is held responsible for his main records, either the records or the work, or both, are apt to suffer.

The draftsmen in the office, post upon the main charts the records as made by the street clerks, and also furnish various reports needed in connection with main work.

Each street clerk is provided with the following equipment:

- 1 45°, 6″ angle
- 1 60°, 4″ angle, for field book
- 1 Brass plumb bob
- 1 Note book, 3¾″x6″, 100 leaves
- 1 Sketch book, 4½″x7⅛″, 60 leaves
- 1 Piece of yellow chalk
- Clips and fasteners of various kinds
- 1 Chalking cord
- 1 Band dater
- 1 Street directory
- 1 Set of ink eradicator
- 1 Combination ink and pencil eraser
- 1 Draftman's soft pencil eraser
- 1 Holder for Daily Progress Report
- 1 Black, blue, red, brown, green and yellow drawing ink
- 1 Set of instructions to street clerks
- 1 Set of drawing instruments
- 2 Ink pads, one red and one black
- 1 3-H lead pencil
- 1 Medium lead pencil
- 1 6′ extension rule
- 1 Piece of soapstone
- 1 Set of rubber stamps
- 1 50′ metallic tape
- Pens, blotters, printed forms and other stationery

FIELD RECORDS.

A field record is made of all openings. A standard field sketch is shown in Fig. 26. As all subsequent records depend upon the field sketch, the measurements are carefully taken and clearly plotted in every detail. Memory is not relied on in any way for information necessary for the final record. A 3-H pencil only is used for this field work. Each sketch is indexed at the back of the field book, alphabetically by its

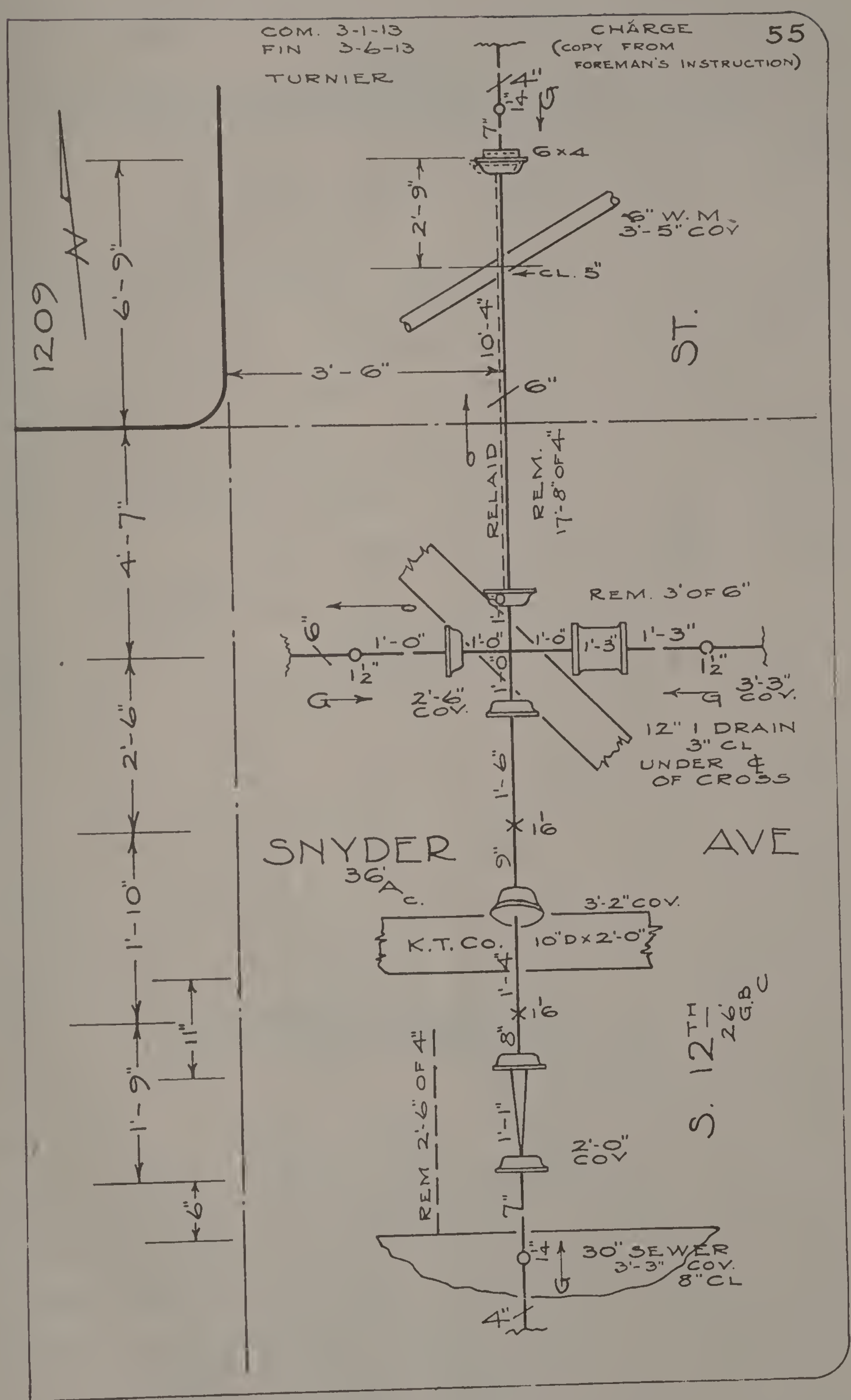


Fig. 26.—Field Sketch. Page 100.

street name, and when the book is full it is turned into the office where it is dated and numbered.

In making field sketches the following points are observed in connection with measurements:

USE OF MEASURING EQUIPMENT.

Fig. 27 shows, in a general way, the application and use of the tape line, measuring rule and plumb bob. The tape line is drawn sufficiently taut to bring it to a straight line, but is never stretched, and as much as possible it is protected from the weather. If it becomes wet or soiled, it is dried before winding into the case. Every two weeks each tape is tested for length against a steel tape. In using the plumb bob, three trials are made for each measurement taken.

MEASUREMENTS: HOW AND WHEN TAKEN.

Curb lines are used as bases of reference wherever possible, otherwise building or fence lines, car tracks, etc. All measurements at right angles to a main or street axis (known as "ordinate" measurements), are taken from the nearest curbs and measured to the centre of the main from the outside edge of the nearest curb. Ordinate measurements are taken at all angle points in the line. Ordinate measurements of foreign structures are always taken with reference to the centre of the nearest gas main, and are to the nearest *edge* of rectangular structures and to the centre of circular structures. Ordinate measurements of foreign structures with reference to curbs are not ordinarily taken.

All measurements parallel with a main or a street axis (known as "axial" measurements) are taken from the intersection of the curb serving as a base for the ordinate measurements, with the intersection, actual or produced, of the nearest curb of the nearest intersecting street. Where streets intersect at angles other than right angles, measurements are taken as shown in Fig. 28. The intersection of the curb lines of such angle streets is obtained by the crossing of the two lines of cord extended along and in line with the curbs whose inter-

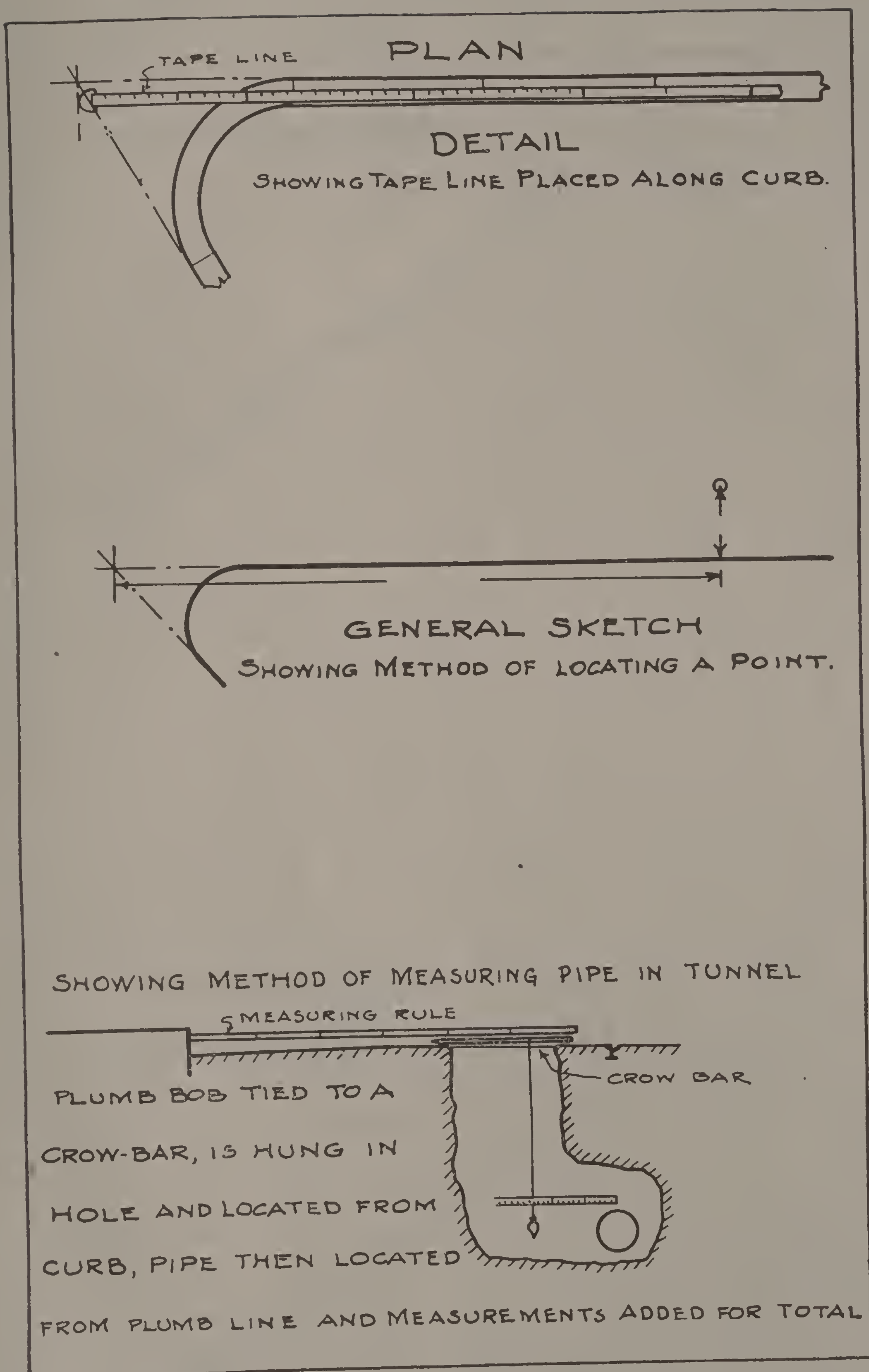


Fig. 27.—Measuring Equipment. Page 102.

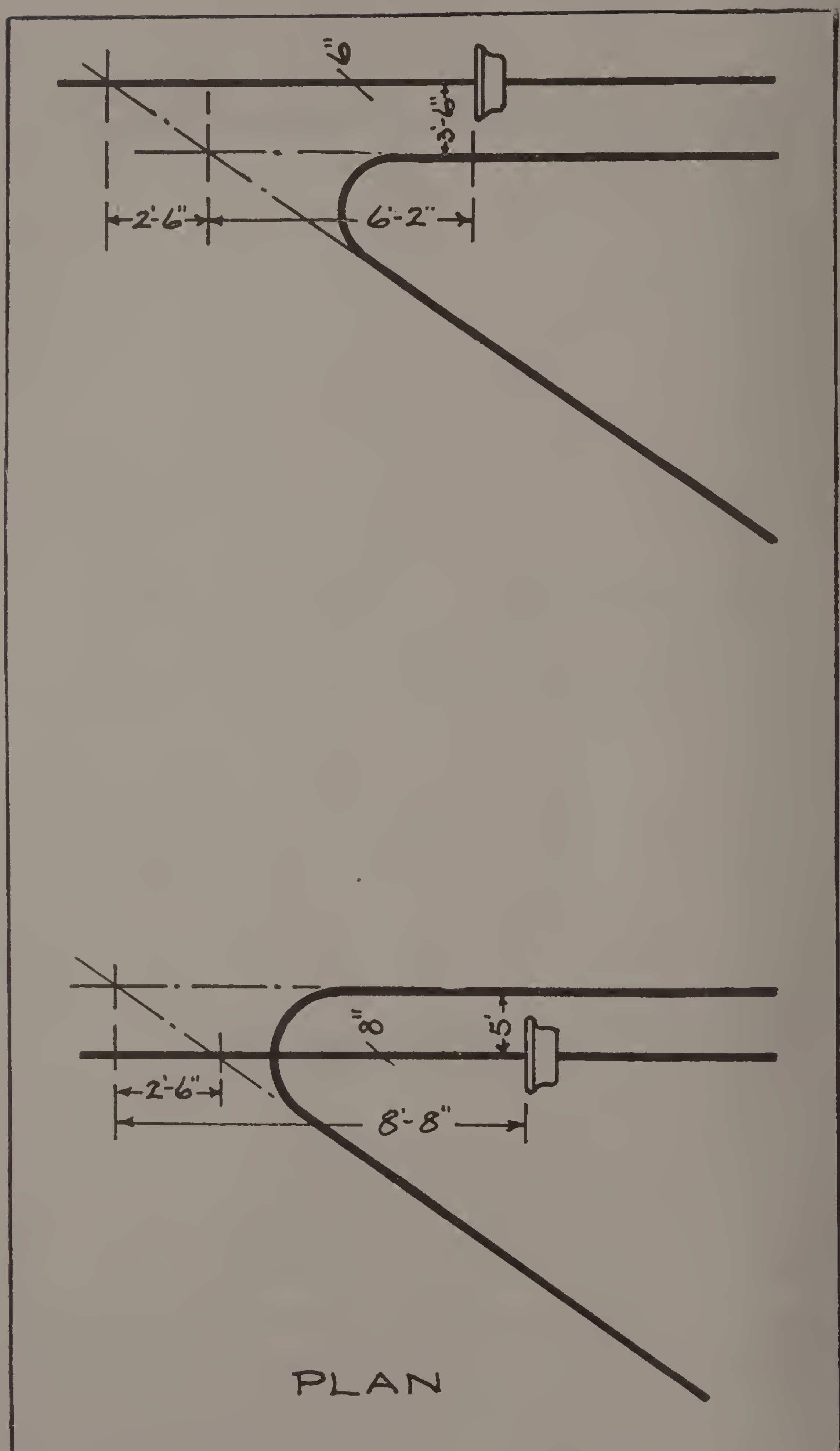


Fig. 28.—Measurements at Other Than Right Angles. Page 102.

section is desired; or by using a chalk line, the intersection may be found with the aid of one cord only.

All depths are taken vertically from the top of the street surface to the top of all structures. Elevations are not shown in the field book unless the structures to be sketched are quite complicated, as it is thought the ordinary plan will not show conditions clearly.

Axial measurements on branches are taken from the intersection of the axes to the face of the nearest bell in all three, or four, directions. Axial measurements on bends are taken for each angle point to the face of the nearest bell, and are measured along the axis of the bend. Axial measurements on Y's are taken from the intersection of the axes to the face of the nearest bell in all three directions. Bushings are counted as being one inch long, and caps as four inches.

Other details that are necessary to bear in mind when taking field records can be stated to better advantage when describing how the permanent records are made.

REPORTS TO OFFICE.

Each day the street clerk makes a report in triplicate, one for the office in the district in which he is working, one for the Records Division and one for himself. This report is made on the form shown in Fig. 29. The form is self explanatory, except possibly as to the information called for in the lines opposite "Laid or Overhauled, Valve, Drip Services, etc." In these cases the character of the work is indicated by drawing a line through the proper significant letter.

PERMANENT RECORDS.

From the field book record a permanent record, known as the "sketch record," is made on the form shown in Fig. 30, whenever any pipe is laid, or old pipe uncovered, of which there is no satisfactory record. This form as well as Fig. 26 is quadrille ruled, not shown by the illustration. Where only a few feet of old straight pipe is uncovered and no foreign structures, the record is made on the form shown in Fig. 31.

No.......... To.......... Inc. DATE ....

MAIN WORK DAILY PROGRESS REPORT

DISTRICT..........

LOCATION	SIDE	SIDE	SIDE	SIDE
INSTRUCTION NO.				
CLASSIFICATION				
SIZE MAIN	"	"	"	"
COMMENCED				
TOTAL LENGTH	'	'	'	'
DATE OF LAST REPORT OF INSTRUCTED JOB				
TOTAL OF LAST REPORT	'	'	'	'
REPORTED TO-DAY	'	'	'	'
TOTAL TO DATE	' TCH	' TCH	' TCH	' TCH
LAID OR OVERHAULED	L O SKB	L O SKB	L O SKB	L O SKB
ABANDONED TO-DAY	—OF "	—OF "	—OF "	—OF "
REMOVED TO-DAY	—OF "	—OF "	—OF "	—OF "
VALVE, DRIP, SERV. OR PRESSURE TEST. STA.	V D S P	V D S P	V D S P	V D S P
FINISHED				
FOREMAN				

LEAKS: ....

REMARKS. ....

....

REC'D R. D. .... ST. CLERK ....

FORM 4—P.G.W. MAKE 3; ORIGINAL TO R. D., KEEP 1, 1 TO DISTRICT. 15M-1-17-13.

Fig. 29.—Progress Report. Page 105.

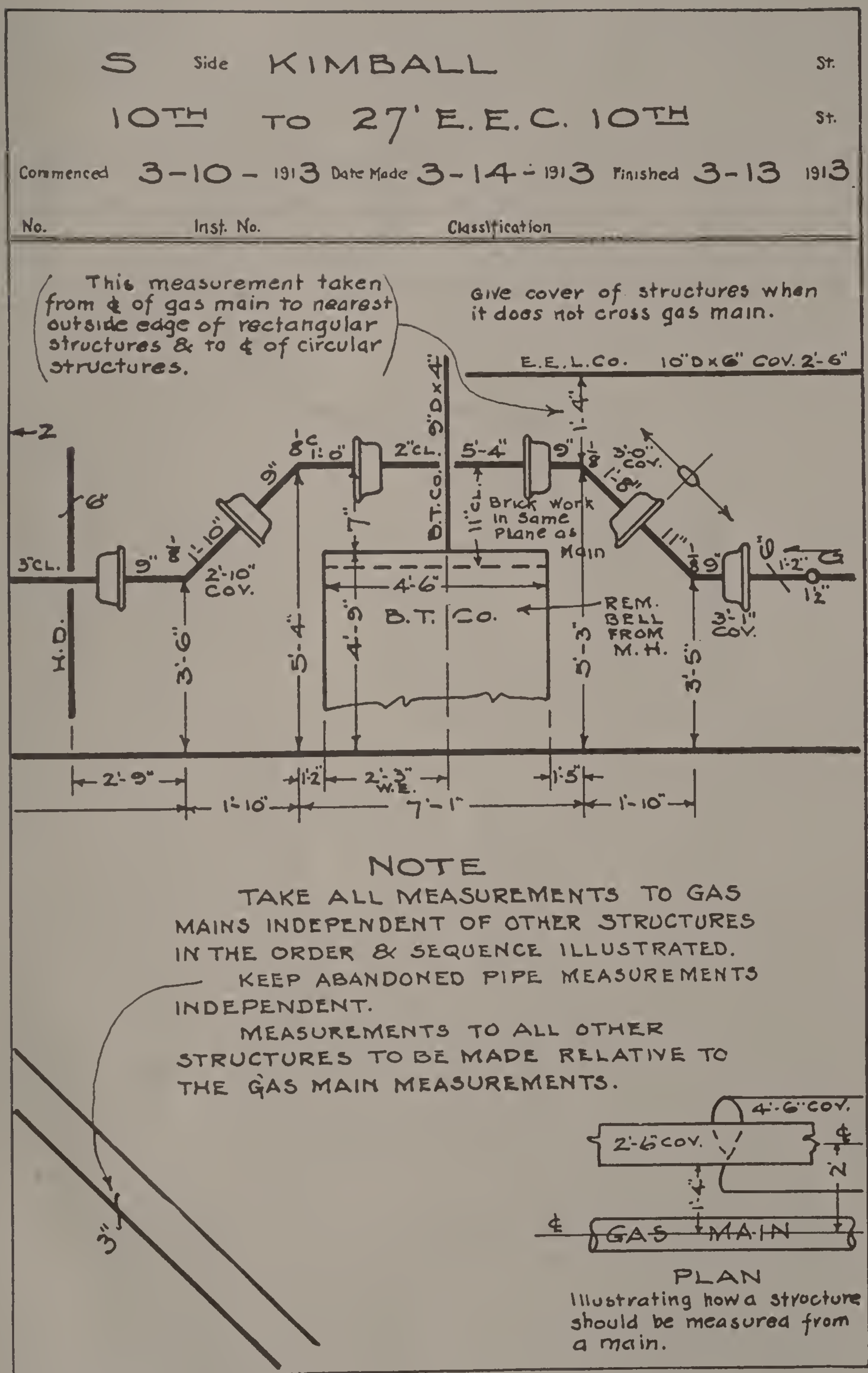


Fig. 30.—Sketch Record Data. Page 105.

SKETCH DETAILS.

In making the sketch record, Fig. 30, the following details are observed: Nothing is drawn to scale, but all of the structures are shown as they exist relatively to each other. The crossing of figures with lines and the crowding of figures, notes and lines are carefully avoided. The name of the street in which most of the work is done is given at the top of the form. The North Point is stamped in red in the upper left corner.

MAIN RECORD. .... District

Nearest house No. .... St.

Charge

Nature of work .... Date ....

Size .... Cover .... Ft. .... Ins. .... Drips towards .... St.

Location of Main .... Ft. .... Ins. .... of .... Curb-line of .... St.

Location of Joint .... Ft. .... Ins. .... of .... Curb-line of .... St.

Kind of Joint .... Joint recaulked .... Yes No. .... Bell faces ....

Foreman .... Kind of paving .... Base .... Kind of soil ....

Location of Foreign Structure .... Size .... Cover ....

Remarks ....

Rec'd B. of R. ....

Sign here ....

Form 33 P. G. W. Make 2—1 to Bureau of Records—1 to District. 10M-6-20-10

Fig. 31.—Main Record Card. Page 105.

In general, the ruled lines of the record card are used in every feasible way, and when possible, the centre lines are used for the mains to be sketched, which are shown by lines 1/32″ wide, according to the following scheme:

*Pipe laid in new work....................solid red
Existing pipe uncovered ....solid black
Pipe abandoned ....solid green
Pipe removed ....broken green
Pipe relaid ....solid red overlaid by broken black

*When wrought iron pipe is used, this fact is stated.

Foreign structures are indicated by lines 1/32″ wide and the following scheme is used:

Water mains .... solid blue
Conduits .... solid yellow
Manholes, handholes, sewers, inlets and
house drains .... solid brown

A separate record is needed where manholes enclose mains. Where a foreign structure is being laid at the same time as a

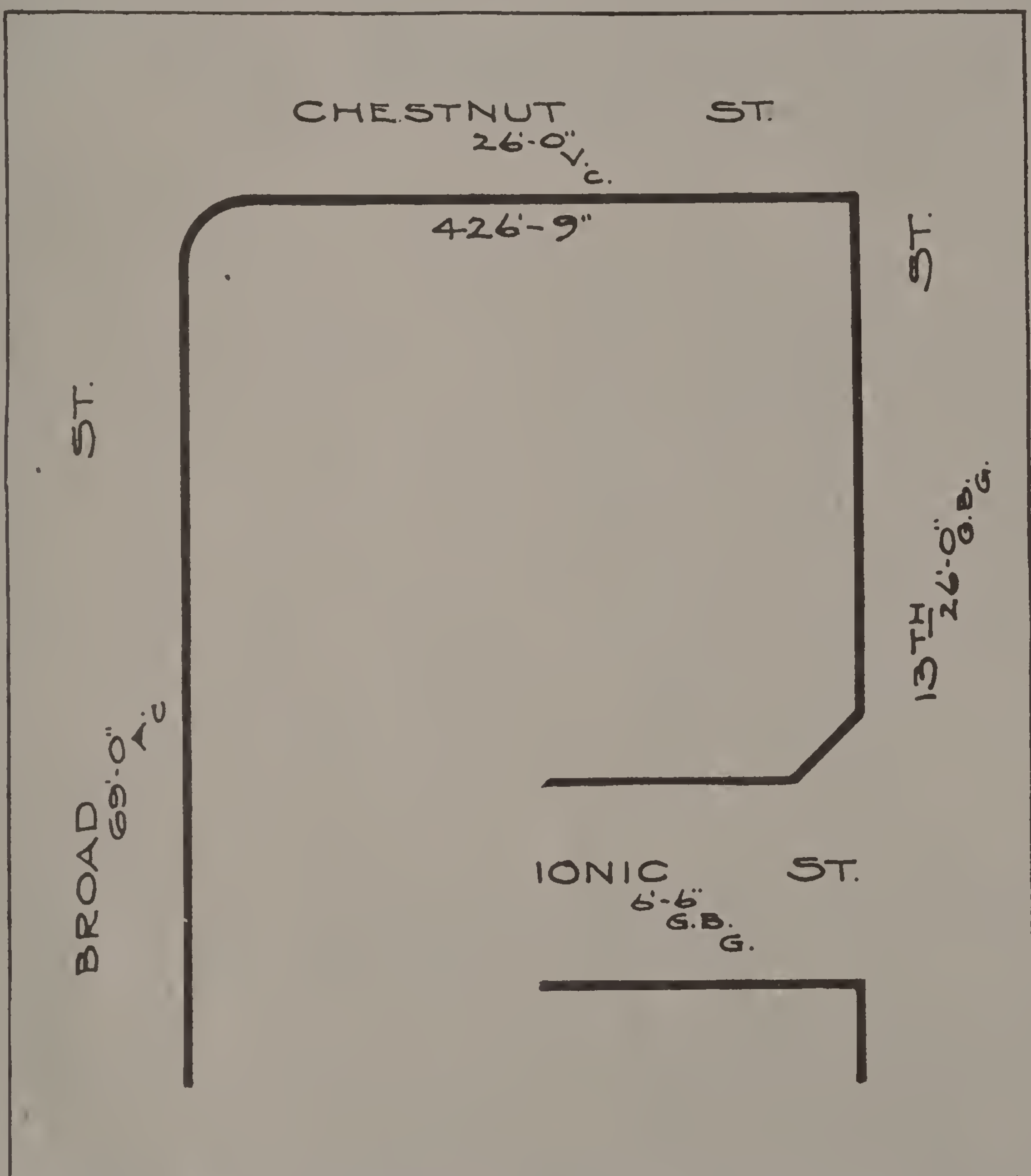


Fig. 32.—Designation of Curbs and Corners. Page 110.

gas main, but is not actually in place when the main record is taken, its approximate location is shown by a dashed line of appropriate color. Clearances are shown in red and give the minimum distances between the main itself and also between a bell and any foreign structure.

Curbs and corners as they exist at time of work are shown by a solid black line 1/32″ wide, as in Fig. 32. Building and dimension lines, etc., are shown as in Fig. 33. Telegraph poles, lamp posts, fire plugs and pier lines, when needed as bases for location, are shown by conventional designs. Figures giving sizes, dimensions, covers, etc., are in black above the line indicating the main, the size being shown at right angles to the main to avoid confusion with dimension and location figures. Solid line rubber hand stamps are used to designate the various

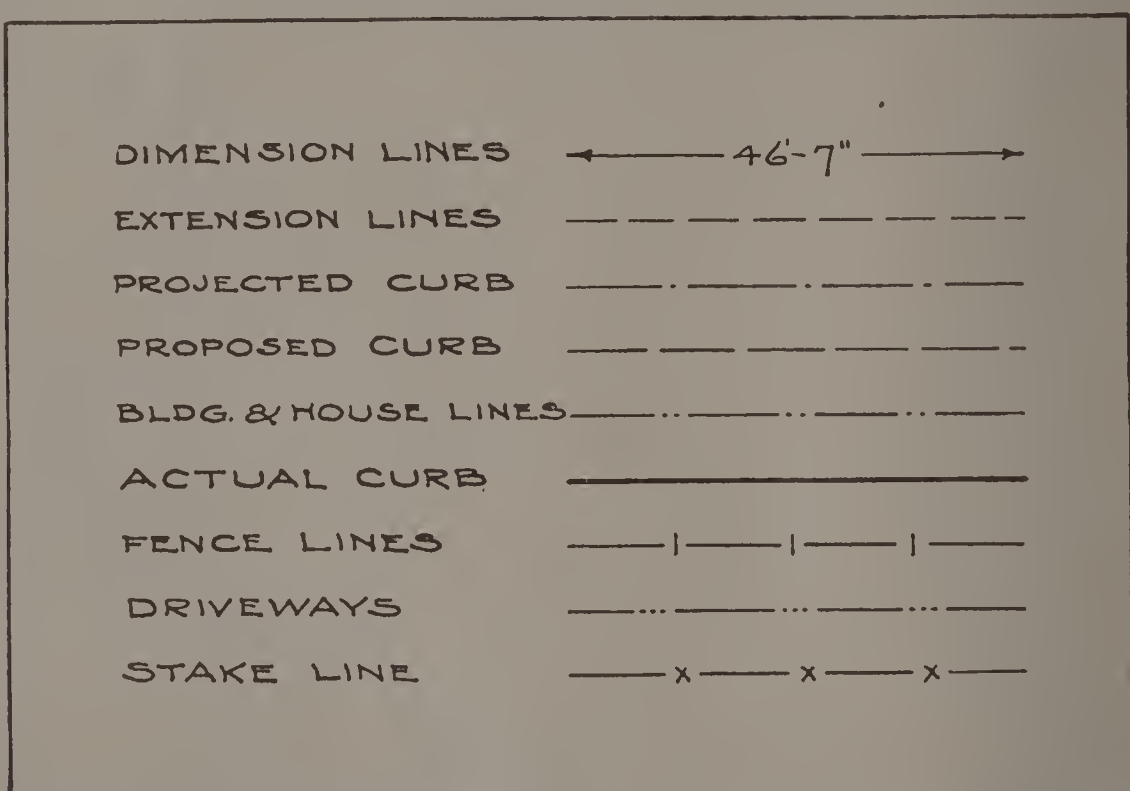


Fig. 33.—Building and Dimension Lines. Page 110.

forms of bells and specials. Reducers are shown solid, tapered to indicate change in size.

When pipe or specials, are only partially exposed, the record indicates this. Under ordinary conditions, the street clerk does not leave in doubt the character of any special only partially uncovered, nor the relations between any intersecting mains.

Where a main is carried through the air, over or under a bridge, detailed information of its location is given. Where a new bridge is being laid, a working plan is always prepared

before the work is begun, and the record made by the street clerk serves as a check against this plan, where the work is carried out as originally intended, or records any difference between execution and plan. Where an existing main is overhauled, and there is no satisfactory record of its location with relation to the bridge, the street clerk secures as detailed a record as may be consistent with safety.

Where pipe is laid above ground for temporary use only, but such use may extend over several months, a special record is made.

Where mains cross under steam railroad tracks, a plan is usually prepared in advance of the work, and the record as taken shows the relation between the tracks and the main, and serves as a check against the plan. In the case of street car tracks, a record of the tracks is not ordinarily taken where the main crosses at right angles, but is always taken where the main is under the track for some distance, as might be the case if the main lies parallel to the track, or crosses under switches.

For each job, in addition to the sketch record made out according to the foregoing rules, all the information needed for the sketch record card is filled out on the reverse of this card, which is shown in Fig. 34.

Of the information contained in the sketch record, there is transferred to the proper main chart only the size and general location of the main, using water colors for easily and quickly washing out, thereby preserving the surface of the chart. When these charts are on a scale no larger than 200 feet to the inch, it is a mistake to indicate on them any details as to specials except the use of fillets to denote connections. When the charts can be obtained on a scale of 50 feet to the inch, a fairly complete record may be made, but the same large scale that makes this detailed record possible allows such a small extent of territory to be shown on any one chart that experience shows the charts on a smaller scale are used for ascertaining the mains in any particular region, while the sketch records must usually be resorted to for certain necessary

FORM. 32 P. G. W. 3M-12 9-12

MAIN WORK SKETCH RECORD.

DISTRIBUTION DEPARTMENT

RECORDS DIVISION

REQ NO. .... AMOUNT AUTH. ....

TOTAL PIPE LAID	PROGRESS REPORT	STRAIGHT PIPE ONLY	LENGTH CEM. LEAD
.... OF	OF	OF	....
"	"	"	
"	"	"	
"	"	"	

TOTAL PIPE OVERHAULED "

.... OF .... "

" "

" .

PLOTTED ON CHART		MONTHLY REPORT	MAINS LAID REPORT	NO. FT.	RECORDED	A. & R. PIPE DRAFTSMAN	BETTERED MAINS DRAFTSMAN	COMPARED FOR NOTES	HIGHWAY SUPERV'S
NO.	DATE			OLD	DATE				
	INITIALS			NEW	INITIALS				

C. I. MATERIAL USED NO.

FOREMAN .... CAULKERS .... NO. ....

.... NO. .... NO. .... NO. ....

REMOVED ....

ABANDONED IN GROUND ....

JOINTS L.. C.. S .... PHOTO. NO. .... ALBUM NO. ....

BUSINESS CLASSIFICATION ...... N. B. ...... A. B. L. A. P. A. R. ... I. P. ....

NATURE OF WORK ....

....

....

....

....

RECEIVED, R. D. ....

.... STREET CLERK

PER .... DUPLICATOR.

(OVER)

Fig. 34.—Sketch Record Card. Page 111.

details which even a scale of 50 feet to the inch cannot show, and therefore the limited use of such a chart does not warrant the expense of preparing it.

The sketch records for the work of the current month are filed until the end of the month in a special file. After the end of the month, when the monthly work has been properly recorded, the sketch records are transferred to the permanent file, where the arrangement is alphabetical by street names, all records for the same street being filed by street number. In order to make this filing by number possible, a hypothetical number is assigned to every record. Where the work involves only a street intersection, or an intersection and more or less work beyond the intersection in the direction in which the street is numbered, the hypothetical number assigned is the highest number belonging to the intersection on the proper side of the street. Where the work does not involve an intersection, or, if involving an intersection, extends beyond it in the opposite direction to the numbering, the number assigned is the lowest one belonging to any building, or lot, on the same side of the street as the work, and in front of which the work is done.

When a record embraces in part, or entirely, the same extent of main covered by a previous record, it is filed behind the earlier record. Where mains are frequently changed, it often happens that a true idea of the exact main location in any one block, or at any one intersection, can only be obtained by reference notes and by spreading out several sketch records made at various times, and noticing carefully how the later records make partial changes in the earlier ones. In this way the very state of affairs, viz., great activity in the installation of underground structures, that renders advisable the adoption of the sketch record system, as opposed to the "blue print" record, previously described, because of the greater ease with which small changes may be shown by means of the sketch record, sometimes produces so many sketch records relating to one block, or intersection, that it becomes advisable to make

what is called a "composite" record. This shows in one record, the block, or intersection, as it is at the time of making the record, and until the future brings new changes, the composite record is the only one that is consulted.

BRIDGE MAINS.

REASONS FOR BRIDGE MAINS.

Until recent years there were no bridges in territories provided with gas mains, except where such territory was divided by a body of water. In many instances, the stream spanned was navigable, and the resultant draw-bridge was of no use as a pipe support. Where the bridge was a fixed one, or where the approaches to a draw-bridge extended over a long stretch of land, marshy or otherwise unfavorable for main laying, in the former case, the whole bridge, and in the latter, the approaches, have been welcomed as a means of facilitating the conveyance of gas across the water.

With the growing abolition of grade crossings of steam railroads, within the limits of towns and cities, has come a great increase in bridges, of which a respectable proportion carry the street over the railroad. If it is necessary or desirable to convey gas across the railroad at any one of these bridges, the choice lies between crossing on the bridge, or laying under the tracks. The latter alternative is usually undesirable for several reasons, of which the two principal ones are as follows: First, the objection of the railroad company, which desires to reduce to a minimum any work by outside persons, in any way affecting the roadbed. If the right of way at the point of crossing is owned in fee simple, permission to cross will be given only on condition of removal on specified notice. This, of course, is not a condition that the gas company cares to accept. In every case the railroad must be held harmless for any damage resulting from the installation or presence of the main; second, the increased expense of installation and maintenance. As a rule, a crossing under the tracks will mean a long stretch of deep main on each side of the bridge, or else

two vertical legs, each about twenty feet, either underground back of the abutment walls, or exposed on the side (usually) of these walls. Invariably the amount of pipe used and its depth will be greater than if the location is upon the bridge.

From what has already been said, it will be seen that the choice will generally be for the bridge crossing, whether over land obstacles, principally railroads, or over water. The disadvantages connected with a bridge main will be considered as the subject is developed.

LOCATION OF MAINS.

When installing a bridge main, the first point to be considered, viz., the necessary permission, is often inter-related with the second, the location. Bridges are generally owned by the public authorities, but sometimes the railroad is joint owner. Unless the addition of extra weight is considered dangerous, permission to lay is seldom refused, but the public authorities are often very much opposed to any location where the main will be in evidence. Generally such a prohibition means a location below the floor line, and entails extra expense in installation and in maintenance, and occasionally where the bridge is over railroad tracks, and the head room is limited, the railroad company interposes with the provision that this head room be not decreased in any way by the proposed main. The exact point at which any prescribed location becomes so disadvantageous as to prevent the bridge main altogether, will, of course, depend entirely upon local conditions. There are, however, some general principles as to location which apply universally.

Where the main girders carrying the bridge, also separate the roadway from the footway, a location on the top of such a girder is ideal. Next in point of desirability, would be on the bridge floor itself, in a corner of the roadway or (preferably) the footway. Blocks of concave top, fitting the main, should raise it one inch above girder, or floor, and a guard timber should protect a roadway floor main.

If there is no location available above the floor line and within the bridge lines, laying along side of the bridge is usually preferable to laying underneath it. Often by attaching brackets to the outside girder, the main can be laid just outside the footway railing, with the bottom of the main about the floor level. If the girder carrying the footway, is deemed too light for additional weight, attachment may be made to the girder at the side of the roadway. This will bring the main under the footway.

There may be instances where the only possible location is under the main floor of the bridge. At the present time, most of the new metal bridges crossing over railroads are protected over their whole bottom from the action of the locomotive gases by a tight wooden sheathing. Only as a very last resort should a pipe be laid in between such sheathing and the bridge floor. So laid, it will at all times be most inaccessible for examination and painting, will be exposed to many corroding influences and escaping gas will be both hard to detect and a great source of danger, forming as it will an explosive mixture inside the sheathing. Where there is no sheathing the choice of location under the bridge will be determined by givng proper consideration to the various elements of first cost, maintenance cost, etc., that may enter into the case.

Where the location is under the bridge, provision should be made at time of installation, for a future means of ready inspection. This generally means building a platform under the pipe, or leaving hangers in which boards may readily be slipped at any time.

So far the types of bridges in mind have been those composed mainly of metal or wood. The advent of re-inforced concrete has brought the concrete arch bridge into the field. With it, location above the bridge floor, or along the bridge sides, is usually prohibited on the score of spoiling the artistic effect. Location under the bridge in the few cases where head room was sufficient, would mean a small stretch of main exposed in an inaccessible place, with most of the pipe buried in

the sides of the bridge arch. This location also pre-supposes the laying of the pipe while the bridge is being built, for it is not probable that permission would be given to tear apart any existing bridge. In most cases, there should be no hesitation in letting the pipe be entirely built into the bridge, its location being usually as low as allowable without exposure on the underside of the arch, in order to avoid contact with the cinder base of the bridge surface. If a leak should develop at a pipe joint there is little chance of gas finding a way out through the concrete. In fact, in a concrete bridge, it is well worth considering where the length is great and the saving would be considerable, whether a cylindrical passage formed in the concrete would not suffice.

PROVISIONS FOR MAINS WHEN DESIGNING BRIDGE.

Except in discussing the concrete bridge, no distinction has been made between a bridge that has been built without any reference to the need for laying mains on it, and a bridge designed after ascertaining what necessary provision should be made for pipe crossings. There is little excuse for any company that allows the erection of a bridge, on which there is a present, or possible future need for a main, without making an attempt to have the location of the main previously settled. Probably in all large cities the official in charge of bridge work notifies the company of each bridge planned and asks them to state their needs as to pipe crossings, and to consult with him as to location. In any locality in default of such notice, it is very easy to have a knowledge of all proposed bridges.

Where the main location is to be alongside, or under, the bridge, the work of laying can be greatly cheapened by suitable openings left in any masonry, and sometimes by holes drilled in, or brackets fastened to a girder, before it is put in place. A good plan in regard to the openings in masonry, is to have the specifications state that the contractor will place thimbles at places designated by the plan, these thimbles to be furnished by

the company. In this way the company is bound to know where the thimbles are to be placed, and their cost is insignificant, consisting as they usually do of spigot pieces of cast iron pipe of a size just large enough to permit the insertion of the bell of the size of pipe being laid.

DESIGN OF MAINS.

MATERIAL.

Ordinary cast iron pipe with lead joints will probably need frequent re-caulking, due to vibration of wood or metal bridges, and also to temperature changes in exposed pipe. With cement joints in sizes 12″ or under, vibration would probably not cause leaks, but temperature changes probably would, and in larger sizes, both vibration and temperatures might be sources of trouble. Where cast iron is buried in a concrete bridge, it is perfectly satisfactory, but the thickness of the bridge at the arch crown may be so slight that the lesser diameter of a wrought iron joint, as compared with a cast iron bell, makes wrought iron pipe preferable for the concrete bridge, as it certainly is for the wood, or metal bridge. On the latter, the saving in space and weight afforded by wrought iron is quite desirable. Also, in the case of under floor locations, the fewer joints and lessened chances for leaks are important points.

JOINTS.

RUBBER.

For mains 6″, or under, in size, the ordinary form of screw coupling is advisable. For 8″ possibly, and for 12″ and over certainly, a rubber or asbestos joint with plain end pipe should be used. As compared with screw pipe, there will be a saving in first cost (always in labor and often in material) and in maintenance, for, as each joint acts as an expansion joint, temperature changes bring no strain on the line, and there should be no leaks.

SCREW.

Where screw joints are used, an expansion joint of some kind is advisable, one for one hundred feet of exposed

pipe. Where there is only one expansion joint, it should be located in the centre of the line; where more than one, they should be equally spaced.

Each expansion joint should be firmly secured to the bridge, in order to prevent any chance of one joint taking up all the movement. At the ends of the line, where the wrought iron joins the cast iron, (usually just before the main goes underground) it is often easy so to locate the necessary specials, that any thrust or pull will be taken up by a swing joint effect.

SIZE.

The size of the bridge main is ordinarily that of the underground main on either side. However, in cold climates, it is probably a mistake to lay smaller than 4″, and in many cases, smaller than 6″. Also, if the region supplied is a growing one, or of large extent, the bridge main should be large enough to care for future growth, especially if the location is such that replacement would be difficult.

The above applies where the main is of moderate size, say 12″ and under. Above 12″, it might often be true that the size of the main very largely added to the expense of the job. If this is the case, it will often prove good practice to make the bridge main smaller than the pipe to which it connects. To what extent this diminution in size is advisable, will depend upon the special conditions in each case, one of the important factors being the length of the bridge, and another the demand for gas during the peak load.

One way of avoiding the use of very large pipe on a bridge, when the size in itself is the objection, is by laying two or more mains. A case in mind is where a concrete arch bridge was built over a single track steam railroad, well in advance of any development on the street which the bridge served, or in the general neighborhood. Future plans for the locality called for a 20″ main on the street. When the city authorities asked what provisions should be made for a gas main, it was soon found that the minimum depth over the arch would not permit of

larger than a 12″ wrought iron pipe. Neither could permission be obtained to lay alongside or on top of the bridge. To go under the railroad was not advisable. Therefore, the decision made was to bury two 12″ wrought iron pipes side by side in the concrete of the bridge. They, of course, will not give the capacity of a 20″, but the bridge is less than 80 feet in length, and the day when the 20″ capacity may be needed is so far ahead, that a third 12″ pipe did not seem justified.

Except where required for real, or assumed, artistic reasons, because of protection from gases of combustion, or because of severe cold, it is not advisable to enclose the main, but instead it should be painted with red lead, covered with a quiet color. A wrought iron pipe kept well painted is bound to be less conspicuous and take less room, than the same pipe boxed. A cast iron pipe with its large bells does not present a neat appearance. A box around the main on the floor, or side, of a bridge is a great collector of dirt, and corrosion will progress faster on a main covered by the ordinary box than if bare. Any covering over the pipe also renders any inspection much more difficult, and any escape of gas more dangerous. However, there are cases where at least a wooden shield under the main, to protect it from the direct impact of the gases from locomotive or boat stacks, is quite necessary.

As to the question of protection from cold, in the old days when a 6″ was a large main, a time honored rule was to make the pipe rising out of the ground, and going over the bridge at least a size larger than the underground pipe. In these days of large mains, it is safe to say that no such practice need be followed for latitudes south of New York City. In Philadelphia, the few cases of exposed mains stopped by frost have been confined to 3″ pipe. Where the climate is severe enough to warrant the enlarging of pipe, then also the question of protecting all exposed pipe needs to be considered. Whatever form of covering is adopted, great care should be exercised to make it water-tight, not only to keep the insulating efficiency high, but also to prevent corrosion. A good quality of canvas,

kept well painted, will especially, when space is limited, form an excellent water-proof cover.

INSPECTION OF MAINS.

All bridge mains being more liable than the underground piping to injury from atmospheric and other external causes. should receive a periodical and careful inspection for condition, in addition to the prefunctory inspection given to them by the line-walker from time to time. This careful inspection should be at least yearly, and a good time is during the fall months, to ensure that everything will be all right for winter. The inspection will usually disclose the necessity for repainting, for minor repairs to platforms and coverings, and in the case of cast iron pipe may mean a resetting of many of the joints. Where pipe is exposed to the action of combustion gases, it is also well to attempt to form an idea of how fast corrosion may be proceeding. A 12″ cast iron pipe exposed under a bridge crossing many busy railroad tracks, was found on removal to have in many places less than ¼″ of metal left.